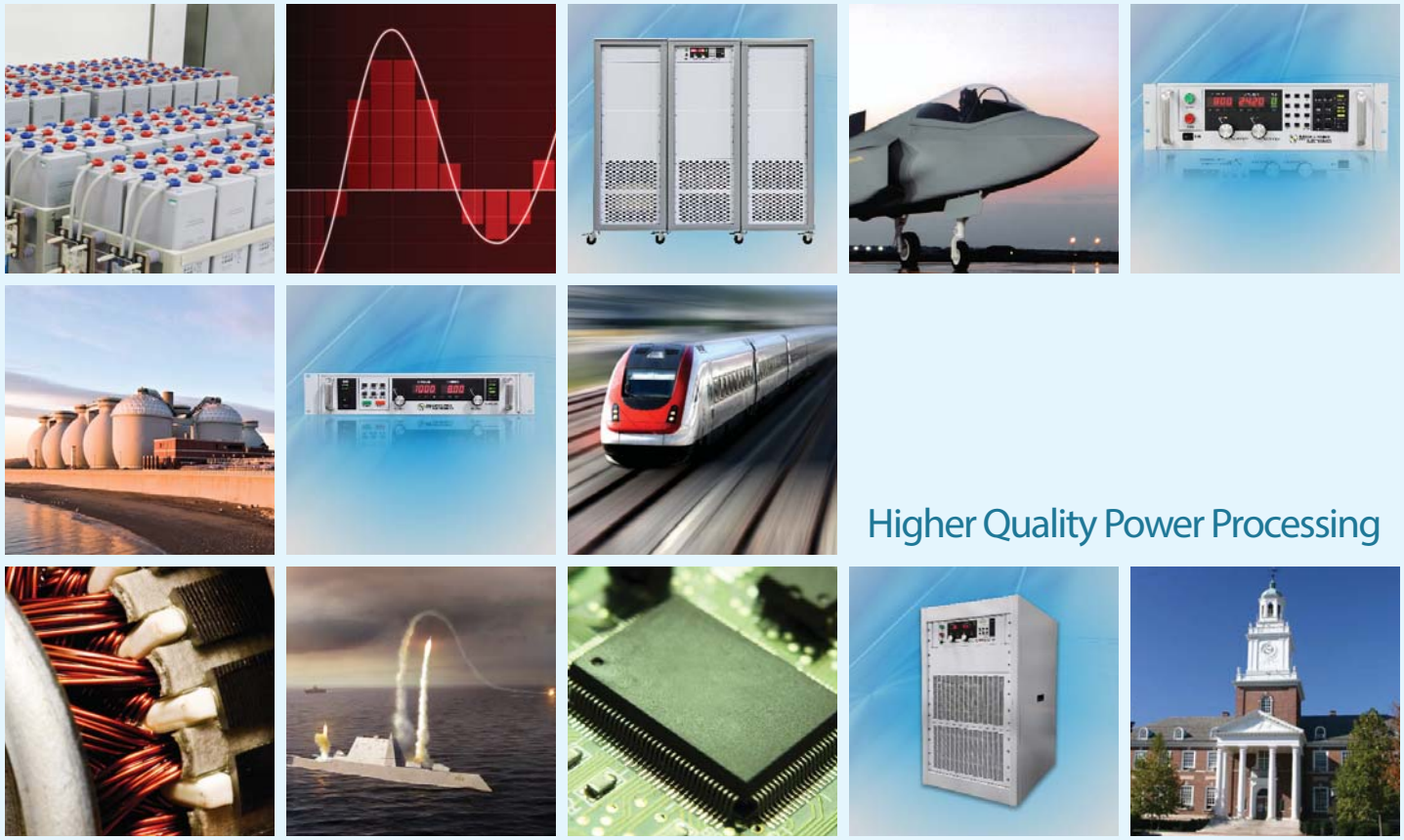
XR Series III User Manual

Programmable DC Power Supply



Higher Quality Power Processing

MAGNA-POWER ELECTRONICS

XR Series 3 User Manual

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This User Manual provides installation instructions, operating procedures, and product specifications for the XR Series III programmable DC power supply. Contents of this User's Guide are subject to change without notice.

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Preface

1. Safety Notice

Before applying power to the system, verify that the unit is configured properly for the user's particular application.

CE recognition of XR Series power supplies is based on rack-mounted applications only. Use of these power supplies outside of a rack mount equipment enclosure will expose the user to high voltage and/or high current sources. Extreme caution must be used under these circumstances.

Two or more XR Series power supplies may be connected in series. Regardless of the number of units or the voltage ratings of the series connected power supplies, the voltage potential from any output terminal to chassis ground should not exceed the product's isolation rating of ±1000 Vdc..

Installation and service must be performed only by properly trained and qualified personnel who are aware of dealing with electrical hazards. Ensure that the AC power line ground is properly connected to the power supply chassis. Furthermore, other power grounds, including those connected to application maintenance equipment, must be grounded for both personnel and equipment safety.

Always ensure that facility AC input power is de-energized prior to connecting or disconnecting the input and output power cables.

Caution: Lethal voltages may be present inside the power supply even when the AC input voltage is disconnected. Only properly trained and qualified personnel should remove covers and access the inside of the power supply.

During normal operation, the operator does not have access to hazardous voltages within the cabinet. Depending on the user's application, high voltages hazardous to human safety may be generated normally on the output terminals. Ensure that the output power cables are properly labeled as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated.

This power supply is designed to be permanently connected to the power source requiring a readily accessible disconnect device incorporated in the fixed wiring.

These operating instructions form an integral part of the equipment and must be available to the operating personnel at all times. All the safety instructions and advice notes are to be followed.

Neither Magna-Power Electronics, Inc. nor any of the associated sales organizations can accept responsibility for personal injury, consequential injury, loss, or damage resulting from improper use of the equipment and accessories.

2. Limited Warranty

The following is made in lieu of all warranties expressed or implied.

Magna-Power Electronics, Inc. warranties its products to be free of manufacturing defects for a period of *two (2) years* from date of original shipment from its factory. Magna-Power Electronics, Inc. will repair, replace, or refund the purchase price at its discretion, which upon examination by Magna-Power Electronics, Inc., is determined to be defective in material or workmanship, providing such claimed defective material is returned upon written authorization of Magna-Power Electronics, Inc., freight prepaid.

For products failing within the first 30 days of the warranty period, Magna-Power Electronics, Inc. will return the repaired product at its expense using a standard shipping method; after 30 days of the

warranty period, the repaired product will be returned at the customer's expense using the customer's requested shipping method.

Damage due to corrosion, customer alterations, excessive dust, extreme environmental or electrical conditions, and/or misuse will be evaluated upon inspection. If inspection reveals that the cause of damage is not due to materials or workmanship, repair of the product will be treated on a non-warranty basis.

All electrical, commercial supply parts, and items not manufactured by Magna-Power Electronics, Inc. shall carry the warranty of the original manufacturer and no more, but under no circumstances to exceed the warranty period. Replacement parts shall be warranted for a period of 90 days.

Warranty labor shall only apply if the product, assembly, or part is returned to the factory freight prepaid and insured. Damage or breakage while in transit is not covered by this warranty.

Magna-Power Electronics, Inc. assumes no responsibility to Buyer for labor to diagnose and remove defective product and installation of replacement product. Furthermore, Magna-Power Electronics, Inc. is not liable to Buyer or to any third party for consequential or incidental damages under any circumstances, whether due to defect in the product, due to delay or failure of delivery, due to a failure of the product to perform as specified, or for any other reason or cause. Buyer and Magna-Power Electronics, Inc. agree that Buyer's sole remedy and Magna-Power Electronics, Inc.'s sole liability to Buyer is limited to repair, replacement, or refund of the purchase price of the product as described herein, whether Buyer's claim arises out of contract or in tort.

All claims against the warranty shall be the final determination of Magna-Power Electronics, Inc.

2.1. Claim for Damage in Shipping

This instrument received comprehensive mechanical and electrical inspections before shipment. Immediately upon receipt from the carrier, and before operation, this instrument should be inspected visually for damage caused in shipment. If such inspection reveals internal or external damage in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. When referring to this equipment, always include the model and serial numbers.

2.2. Returning Equipment

Before returning any equipment to the factory, the following steps should be observed:

- Contact our technical service department or file a RMA request (http://www.magna-power.com/support/rma-request). Give a full description of the difficulty and include the model and serial number of the unit. Upon receipt of this information, we will give you service information or shipping instructions.
- Packaging and method of shipment must be coordinated with the factory to insure safe delivery. All equipment returned for repair requires a Return Authorization Number and must be insured. No returns will be accepted without assignment of a Return Authorization Number.
- For non-warranty repairs, we will submit a cost estimate for your approval before proceeding.

3. Declaration of Conformity

The Declaration of Conformity is included with all products on the calibration certificate. An additional digital copy is available by request at no charge for all Magna-Power Electronics products. To receive

an additional digital copy of the product's Declaration of Conformity, email your product's serial number to support@magna-power.com

4. Document Conventions

This user's manual uses several conventions to highlight certain words and phrases and draw attention to specific pieces of information.

In PDF and paper editions, this manual uses typefaces drawn from the *Liberation Fonts*[1] set. The Liberation Fonts set is also used in HTML editions if the set is installed on your system. If not, alternative but equivalent typefaces are displayed.

4.1. Notes and Warnings

Note

Notes are tips, shortcuts or alternative approaches to the task at hand. Ignoring a note should have no negative consequences, but you might miss out on a time saving procedure.

4.1.1. Safety Symbols

Table 1, " Safety Symbols" defines the IEC symbols used throughout this Users Manual for the XR Series III.

Table 1. Safety Symbols

Symbol	Definition
	Earth ground, protective conductor terminal
	Caution, risk of electric shock
	Caution, risk of danger
	Three-phase alternating current

4.2. Text Conventions

Source-code listings are also set in **`mono-spaced roman`** but add syntax highlighting as follows:

```
package org.jboss.book.jca.ex1;
```

[1] https://fedorahosted.org/liberation-fonts/

```
import javax.naming.InitialContext;

public class ExClient
{
   public static void main(String args[])
       throws Exception
   {
      InitialContext iniCtx = new InitialContext();
      Object         ref    = iniCtx.lookup("EchoBean");
      EchoHome       home   = (EchoHome) ref;
      Echo           echo   = home.create();

      System.out.println("Created Echo");

      System.out.println("Echo.echo('Hello') = " + echo.echo("Hello"));
   }
}
```

Terms and definitions are highlighted as follows:

Sample title for reference and definition list

Sample Term

Sample Definition

5. Getting Help and Giving Feedback

5.1. Additional Support

If you experience difficulty with a procedure described in this documentation, visit the Magna-Power Electronics Support Portal at *http://www.magna-power.com/support*. Through the Support Portal, you can:

- Search or browse through a knowledge base of technical support articles about Magna-Power Electronics products
- Access the most up-to-date searchable and browseable product documentation, such as this User's Manual
- Review application notes and guides for key product applications

5.2. Feedback

If you find a typographical error in this manual, or if you have an idea how to make this manual better, we would like to hear from you. Please submit an email report to: support@magna-power.com against the product **XR Series III.**

When submitting a bug report, be sure to mention the manual's identifier: *XR Series III User Manual*

If you have a suggestion for improving the documentation, try to be as specific as possible when describing it. If you have found an error, please include the section number and some of the surrounding text so we can find its location.

Product Information

This chapter introduces the technology behind the XR Series III Programmable DC Power Supply

1.1. Key Features

Magna-Power Electronics XR Series III combines the best of DC power processing with microprocessor embedded control. Magna-Power Electronics innovative power processing technology improves response, shrinks package size, and reduces cost. XR Series III power supplies are current-fed and are more tolerant to abusive loads than conventional switching power supplies.

XR Series III power supplies can operate as a voltage source or a current source depending on the control settings and load conditions. If the power supply is operating as a voltage source and the load increases to a point beyond the current command setting, the power supply automatically crosses over to current mode control and operates as a current source at that setting.

XR Series III power supplies incorporate an optically isolated feedback system. The result is that all user interface circuitry is referenced to earth ground, not the negative terminal of the power supply. This enables users to connect external circuitry without concern of ground loops or voltage breakdown, up to the full isolation rating of the power supply.

XR Series III power supplies offer both master/slave parallel and series operation. This enables two or more power supplies to be placed in parallel for increased output current or in series for increased output voltage. With master/slave operation, power supplies operate at near equal voltage and current.

XR Series III power supplies can be configured through the front panel for different applications. The power supply can be programmed to have its control functions accessible from the front panel, rear 37-pin connector, or with RS232, IEEE-488 GPIB (+GPIB), or LXI TCP/IP Ethernet (+LXI) communications. External RS485 to RS232 (+RS485) and external USB to RS232 (+USB) converters are also available to echo commands over the communications network. Communication options must be specified at time of order. XR Series III power supplies support a full set of SCPI commands. IVI drivers are available which support programming in Visual C++, Visual C#, Visual Basic .NET, Visual Basic 6.0, LabVIEW, LabWindows/CVI, MATLAB, Measure Foundry, and Agilent VEE Pro.

Sensing can be established at the output terminal of the power supply or through a rear terminal block for remote sensing at the load. A smart remote sense detector checks whether or not sense leads are present eliminating the potential of uncontrolled operation. An external interlock can be set to enable operation only when an external connection is made. Even calibration has been simplified with front panel access to calibration digital potentiometers.

XR Series III power supplies have three levels of over voltage/current protection: shutdown of controlling insulated gate bipolar transistors (IGBTs), disconnect of main power, and input fuses. After an over voltage/current trip condition, the supply must be reset using the Clear functionality.

XR Series III power supplies have push button start/stop controls. These controls are tied to a mechanical contactor which operates with the electronic switches to break the AC mains when stop is commanded. Off means both an electrical and mechanical break in the power circuit—not just a break in an electronic switch. Safety comes first at Magna-Power Electronics.

XR Series III power supplies are available with two alternative front panels: XR Version for analog/digital control and C Version for computer or programmable logic control. All XR Series III power supplies employ the same power processing engine.

XR Series III models utilizing the XR Version front panel provide stepless analog control from front panel potentiometers. With simple configuration changes, voltage, current, over voltage trip, and over current trip may be programmed from the 37-pin isolated I/O, RS232, IEEE-488 GPIB (+GPIB), LXI

TCP/IP Ethernet (+LXI), Edgeport USB (+USB). XR Series III power supplies with XR Version front panels are well suited for industrial and laboratory applications.

XR Series III power supplies with the XR Version front panels offer an analog input to modulate the voltage or current setting using piecewise linear approximation. This feature enables the voltage or current setting to be adjusted by a sensor input, such as a thermistor, or by monitoring its own voltage or current. Modulation allows the output to be tailored for advanced process control applications, battery charging, and source emulation.

XR Series III models utilizing the C Version front panel only allow control from the 37-pin isolated I/O, RS232, IEEE-488 GPIB (+GPIB), LXI TCP/IP Ethernet (+LXI), or Edgeport USB (+USB). These models are intended for process control applications where front panel controls and displays are not required or desired.

Remote Interface Software is included to provide sophisticated computer control. This software provides a virtual control panel to emulate the power supply's front panel, a command panel to send and monitor SCPI commands, a register panel to monitor registers, a calibration panel to provide easy access to calibrate digital potentiometers, a firmware panel to upgrade the control microprocessor, and a modulation panel to easily program modulation parameters.

XR Series III models have extensive diagnostic functions—all of which when activated take command to shut down the system. Diagnostic functions include phase loss, excessive thermal conditions, over voltage trip, over current trip, and program line. Program line monitors externally applied analog set point signals to insure they are within the specified range. Upon a diagnostic fault condition, main power is disconnected and the diagnostic condition is latched into memory. Pressing the clear key clears the memory. All diagnostic functions can be monitored through a rear connector. Furthermore, control functions can also be set through the rear connector to allow simultaneous control of one or more XR Series III units.

Finally, XR Series III models rated for 16 Vdc and above have a novel electronic output stage that utilizes near constant power loading under all conditions via an electronic bleed resistance. This electronic bleeder means stability under all operating conditions and faster fall times, without affecting the overall system efficiency.

1.2. Principle of Operation

This section provides a general overview of the technology and power processing stages in a Magna-Power Electronics XR Series III. *Figure 1.1, “XR Series III functional block diagram”* provides an visual overview of the power supply's main power and control stages.

Power is fed through AC fuses and is distributed to the auxiliary power supply, inrush limiter, and main 3Φ contactor. The auxiliary power supply operates off the AC mains, supplying power to the other printed circuit boards in the system. The inrush limiter is a step start device which is used to initially charge capacitors on the input DC bus and limit the inrush of current. The inrush limiter is initiated when the power supply is switched from a standby to a power state. After the charge cycle, the main 3Φ contactor is energized and power is allowed to flow to the load. The EMI filter reduces common mode and differential mode noise emanating from the supply.

Output power is controlled through a polyphase chopper. For a 6 kW and 8 kW XR Series III power supplies, three choppers, phased 120° apart, provide a current source to a current fed inverter. The 4 kW XR Series III power supplies uses two choppers, phased 180° apart, and the 2 kW supplies uses only one chopper. The choppers are controlled with current mode, pulse width modulation (PWM). This modulation scheme provides a quick response for transients and filtering harmonics on the DC bus. As illustrated, chopper output current is monitored for balancing and for sensing overload current conditions. The polyphase chopper has been engineered to eliminate harmonic components minimizing currents circulating in the power supply.

The polyphase chopper produces a controlled DC bus which is connected to DC link inductors and current fed, IGBT inverter. The inverter, which operates above 20 kHz, excites the main transformer at higher than normal line frequencies. This operation produces ohmic isolation between the input and output of the power supply using a transformer of dramatically reduced size.

The inverter operates with a 50% duty cycle and its frequency operation is transparent to the performance of the power supply.

The output of the main power transformer is converted to DC via rectifiers. Low voltage versions of the XR Series III power supply use midpoint diode configurations and higher voltage versions use bridge configurations.

The DC output voltage is filtered with a pie section filter. This, in combination with the DC link inductors, form a double stage inductive capacitive (LC) filter.

The gate driver board supports a synchronized modulation scheme which integrates power semiconductor switching of the switching power supply, polyphase chopper, and IGBT inverter.

The phase detector senses input line voltage on each phase. Upon detection of a problem, the control board is signaled to shutdown the system. The control board, which is referenced to earth ground, contains optically isolated amplifiers to sense output voltage and current. This circuitry allows the output to be referenced ±1000 Vdc above earth ground.

The display board contains light-emitting diodes for displaying diagnostic conditions and provides an interface for meters and switches.

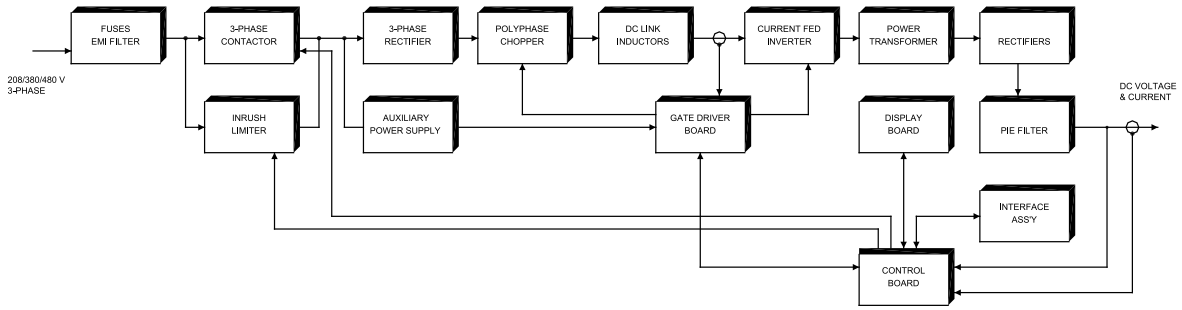

Figure 1.1. XR Series III functional block diagram

1.3. Specifications

This section details the product specifications for the XR Series III. If additional product specifications are required, please contact Magna-Power Electronics by emailing support@magna-power.com. Make sure to include your product's model and serial number along with your desired specification.

Specifications are subject to change without notice. For three-phase configurations, input specifications are line-to-line, specified at 208 Vac, 380 Vac, and 440 Vac input. Unless otherwise noted input voltages and currents are specified for three-phase configurations.

Table 1.1. XR Series III Physical Specifications

Physical Specifications		
Power	**Size (H" x W" x D")**	**Weight**
2 kW	3.50 x 19 x 24 in (8.89 x 48.3 x 61.0cm)	45 lbs. (20.41 kg)
4 kW	3.50 x 19 x 24 in (8.89 x 48.3 x 61.0cm)	47 lbs. (20.32 kg)
6 kW	3.50 x 19 x 24 in (8.89 x 48.3 x 61.0cm)	48 lbs. (20.77 kg)
8 kW	3.50 x 19 x 24 in (8.89 x 48.3 x 61.0cm)	48 lbs. (20.77 kg)

Table 1.2. XR Series III Input Specifications

Input Specifications	
Nominal Voltage 3 phase, 3 wire + ground	208 Vac, 3Φ (operating range 187 - 229 Vac) 240 Vac, 3Φ (operating range 216 - 264 Vac) 380 Vac, 3Φ (operating range 342 - 418 Vac) 415 Vac, 3Φ (operating range 373 - 456 Vac) 440 Vac, 3Φ (operating range 396 - 484 Vac) 480 Vac, 3Φ (operating range 432 - 528 Vac)
1 phase, 2 wire + ground (2 kW Models Only)	208 Vac, 1Φ (operating range 187 - 229 Vac) 240 Vac, 1Φ (operating range 216 - 264 Vac)
Frequency	50 Hz - 400 Hz (operating range 45 - 440 Hz)
Power Factor	> 92% at maximum power

Table 1.3. XR Series III Output Specifications

Output Specifications	
Ripple	(See *Table 1.6, "XR Series III Models"*)
Line Regulation	Voltage Mode: ±0.004% of full scale Voltage Mode: ±0.02% of full scale
Load Regulation	Voltage Mode: ±0.01% of full scale Current Mode: ±0.04% of full scale
Load Transient Response	2 ms to recover within ±1% of regulated output, with a 50% to 100% or 100% to 50% step load change
Efficiency	> 86% at full load (See *Table 1.6, "XR Series III Models"*)
Stability	±0.10% for 8 hrs. after 30 min. warmup
Isolation	Use inputs and outputs referenced to earth ground Maximum input voltage to ground ±2500 Vac Maximum output voltage to ground ±1000 Vdc
Maximum Slew Rate	**Standard Models:** 100 ms for output voltage change from 0 to 63% 100 ms for output current change from 0 to 63% **With High Slew Rate Option (+HS):** 4 ms for output voltage change from 0 to 63% 8 ms for output current change from 0 to 63%
Bandwidth	**Standard Models:** 3 Hz for remote analog voltage programming 2 Hz for remote analog current programming **With High Slew Rate Option (+HS):** 60 Hz for remote analog voltage programming 45 Hz for remote analog current programming

Table 1.4. XR Series III Control Specifications

Control Specifications	
Voltage Programming Accuracy	±0.075% of full scale voltage
OVT Programming Accuracy	±0.075% of full scale voltage
Current Programming Accuracy	±0.075% of full scale current
OCT Programming Accuracy	±0.075% of full scale current
Voltage Readback Accuracy	±0.2% of full scale voltage

Control Specifications	
Current Readback Accuracy	±0.2% of full scale current
External Analog Programming and Monitoring Levels	0 - 10 Vdc
External Analog Output Impedances	Voltage output monitoring: 100Ω Current output monitoring: 100Ω +10V reference: 1Ω
External Digital Programming and Monitoring Limits	Input: 0 to 5 Vdc, 10kΩ input impedance Output: 0 to 5 Vdc, 5 mA drive capacity
Remote Sense Limits	3% maximum voltage drop from output to load

Table 1.5. XR Series III Environmental Specifications

Environmental Specifications	
Ambient Operating Temperature	0°C to 50°C
Storage Temperature	-25°C to 85°C
Humidity	Relative humidity up to 95% non-condensing
Temperature Coefficient	0.04 %/°C of maximum output voltage 0.06 %/°C of maximum output current
Air Flow	Side air inlet, rear exhaust

XR Series III Agency Approvals

EN61010-1:2001-02
: Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

2004/108/EC
: EMC Directive

EN61000-6-3:2001 and EN61000-6-3:2001
: General Emissions Standard

EN55022 Class A
: Product Specifications Emissions

EN61000-6-1:2001
: Generic Immunity Standard, including the following cross references: EN61000-4-2 (Electrostatic Discharge), EN61000-4-3 (Radiated Susceptibility), EN61000-4-4 (Electrical Fast Transient/Burst), EN61000-4-6 (Conducted Susceptibility), EN61000-4-8 (Magnetics), EN61000-4-11 (Voltage Dips and Interruptions)

1.4. Models

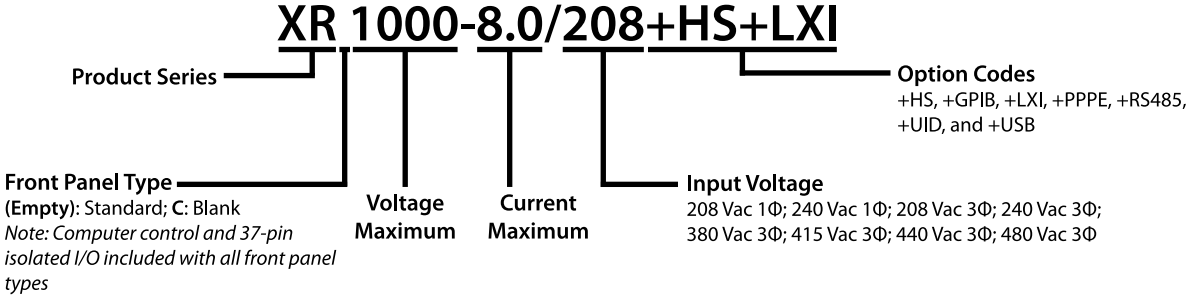
XR 1000-8.0/208+HS+LXI
Product Series
Option Codes
+HS, +GPIB, +LXI, +PPPE, +RS485, +UID, and +USB
Front Panel Type
(Empty): Standard; C: Blank
Note: Computer control and 37-pin isolated I/O included with all front panel types
Voltage Maximum
Current Maximum
Input Voltage
208 Vac 1Φ; 240 Vac 1Φ; 208 Vac 3Φ; 240 Vac 3Φ; 380 Vac 3Φ; 415 Vac 3Φ; 440 Vac 3Φ; 480 Vac 3Φ

Figure 1.2. XR Series III model ordering guide

Table 1.6, "XR Series III Models" details the available standard XR Series III models. The Current Maximum (Adc) column is separated by the available power levels. To determine the appropriate model, first select your output Voltage Maximum (Vdc) to find appropriate row. Next, select one desired Current Maximum from the row that contains your desired Voltage Maximum. Then, construct you model number according to the *Figure 1.2, "XR Series III model ordering guide"*. Non-standard voltage and current configurations are available.

Table 1.6. XR Series III Models

	2 kW	4 kW	6 kW	8 kW		
Voltage Maximum (Vdc)	**Current Maximum (Adc)**				**Ripple (mVrms)**	**Efficiency (%)**
5	375	N/A	N/A	N/A	50	86
10	200	375	N/A	N/A	40	86
16	125	250	375	N/A	35	86
20	100	200	300	375	40	86
32	62	124	186	250	40	86
40	50	100	150	200	40	87
50	40	80	120	160	50	87
80	25	50	75	100	60	87
100	20	40	60	80	60	87
125	16	32	48	64	100	87
160	12	24	36	50	120	87
200	10	20	30	40	125	87
250	8	16	24	32	130	88
375	5.3	10.6	15.9	21.3	170	88
400	5.0	10.0	15.0	20.0	180	88
500	4.0	8.0	12	16.0	220	88
600	3.3	6.6	9.9	13.3	250	88
800	2.5	5.0	7.5	10.0	300	88
1000	2.0	4.0	6.0	8.0	350	88
	Maximum Input Current (Aac)					
208/240 Vac, 3Φ	8	15	22	29		
208/240 Vac, 1Φ	16	N/A	N/A	N/A		
380/415 Vac, 3Φ	5	9	13	17		
440/480 Vac, 3Φ	4	8	11	15		

1.5. Diagrams and Indicators

This section provides diagrams detailing the XR Series III front panel layout and physical dimensions. The definitions for the digram references are detailed in after the diagrams.

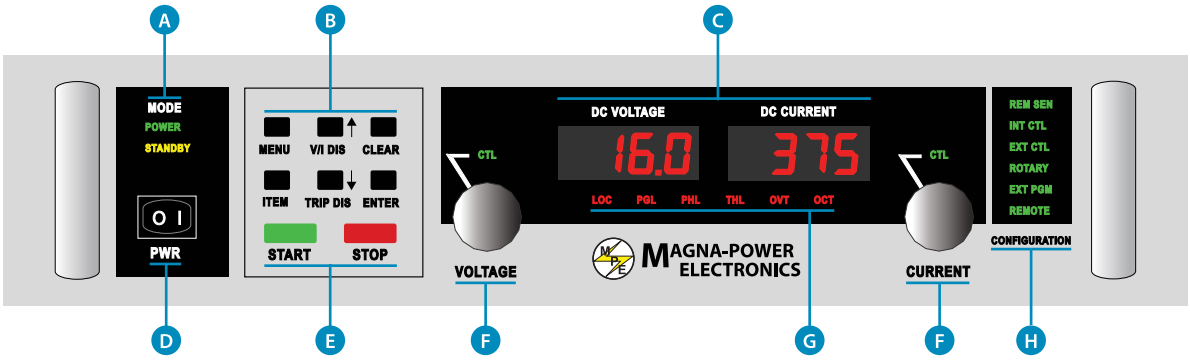

Figure 1.3. XR Version front panel layout

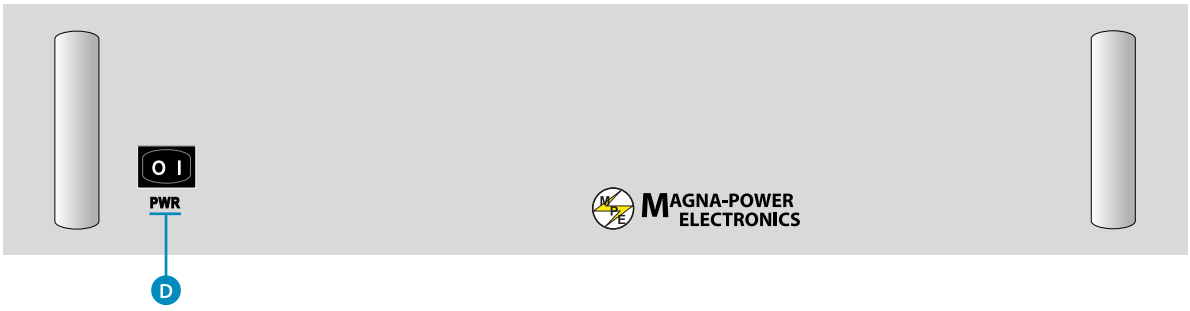

Figure 1.4. XRC Version front panel layout

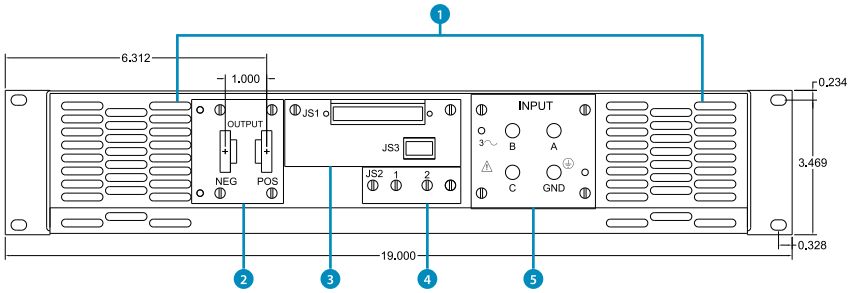

Figure 1.5. XR Series III rear panel layout and dimensions

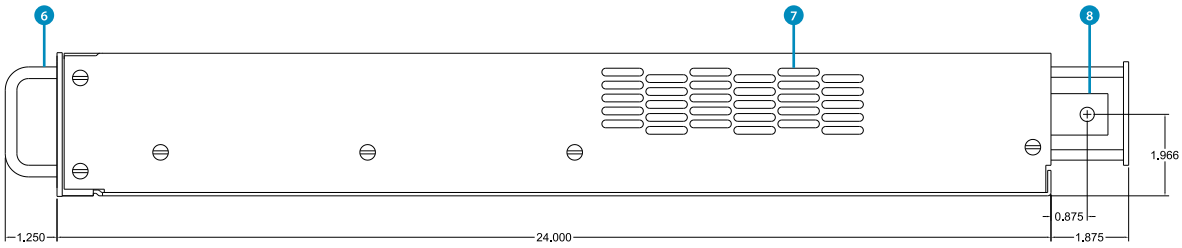

Figure 1.6. XR Series III side panel layout and dimensions

Front Panel Definitions

A (MODE)

POWER: Indicates power output

STANDBY: Indicates control power only

B (FUNCTION KEYS)

MENU: Selects function

ITEM: Selects item within function

Rear and Side Panel Definitions

1

Rear Air Exhaust

2

Output DC Connections (Front View)

3

Computer and External Control Connections

V/I DIS: Displays voltage/current settings
TRIP DIS: Displays OVT and OCT settings
CLEAR: Clears setting or resets fault
ENTER: Selects item

C

Meters display output voltage, output current, voltage set point, current set point, over voltage trip, and over current trip

D

Power switch energizes control circuits without engaging main power

E

Engages and disengages main power

F

Stepless rotary knob to set voltage/current

G (DIAGNOSTIC ALARMS)

LOC: Interlock
PGL: External input voltage beyond limits
PHL: Indicates under-voltage AC input
THL: Indicates over-temperature condition
OVT: Over-voltage protection has tripped
OCT: Over-current protection has tripped

H (CONFIGURATION)

REM SEN: Remote sense enabled
INT CTL: Front panel start/stop/clear enabled
EXT CTL: External start/stop/clear enabled
ROTARY: Front panel control
EXT PGM: External voltage/current control
REMOTE: Computer control

4

Remote Sensing Connector

5

Input AC Connections, 10-32 Threaded Insert, Qty (4)

6

Front Panel Handles

7

Side Air Intake

8

Output DC Connections (Side View), 0.250 x 1.000 Tin Plated Copper Bus, 3/8-16 Threaded Insert, Qty (2)

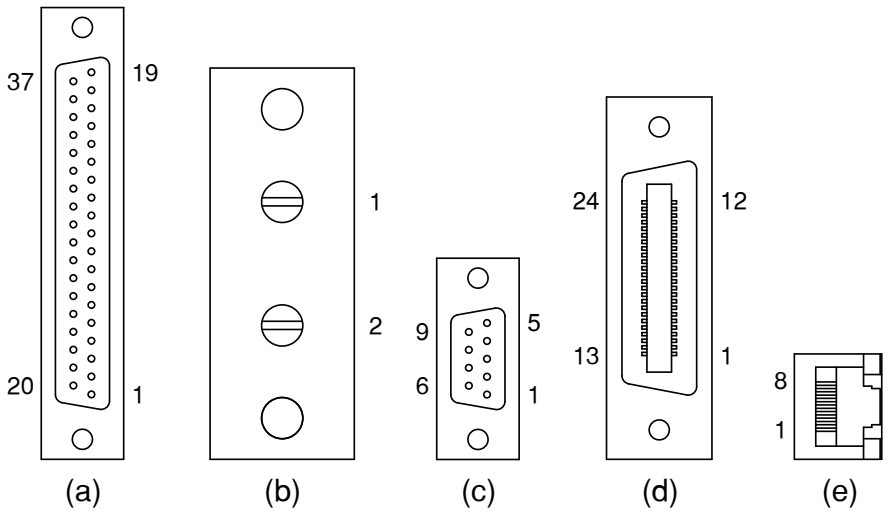

Figure 1.7. XR Series III communication connections: (a) JS1, external program interface; (b) JS2, remote sense; (c) JS3, RS232; (d) JS4, IEEE-488 GPIB; and (e) JS5, LXI TCP/IP Ethernet (viewed from female end)

1.6. Product Options

This sections provides details on all the available options for all Magna-Power Electronics Programmable DC Power Supply products. Note that not all options may be available for the XR Series III.

1.6.1. High Isolation Output (+ISO)

Certain applications require floating the output voltage to values beyond the power supply isolation rating. Magna-Power Electronics High Isolation Output Option (+ISO) enables any TS Series, MS Series, or MT Series model with a peak output voltage rating of 250 Vdc through 1000 Vdc to be rated for a higher voltage output isolation. Improved isolation is achieved by a novel output stage with improved controller isolation. In addition to being able to float the power supply to a higher output voltage, this option also enables lower voltage units to be tied together in series up to the higher isolation rating.

Table 1.7, "(+ISO) Option Isolation Specifications" provides the output isolation rating for all available configurations, where Vo is the unit's rated maximum output voltage.

Table 1.7. (+ISO) Option Isolation Specifications

Product	Isolation, models 1000 Vdc and below	Isolation, models 1000 Vdc and below with +ISO option	Isolation, models above 1000 Vdc
XR Series	1000 Vdc	N/A	N/A
TS Series	1000 Vdc	±(2000 Vdc + Vo/2)	±(2000 Vdc + Vo/2)
MS Series	1000 Vdc	±(2000 Vdc + Vo/2)	±(2000 Vdc + Vo/2)
MT Series	1000 Vdc	4000 Vdc	4000 Vdc

1.6.2. High Slew Rate Output (+HS)

The high slew rate option solves several limitations inherent in switching power supply design. Rapid voltage transitions require internal electronics to supply the energy to charge and discharge output capacitors. Peak currents internal to the power supply define slew rate; utilizing less capacitance enables voltage transitions in shorter time periods. Additionally, less capacitance reduces requirements for discharge demands during open circuit conditions.

The standard output stage Magna-Power Electronics power supplies has been designed to provide the lowest possible output ripple voltage within the constraints of available components, size, and cost. Part of the output stage consists of a bank of aluminum electrolytic capacitors which has the desired electrical properties to provide this function. These components require bleed resistors to discharge any voltage when the power supply has no load and is disabled. While the presence of these components and the resulting performance are normally industry accepted, there are applications where lower output capacitance is extremely desirable and higher ripple voltage is acceptable. To meet this need, a high-slew rate option is available which has an output stage consisting of low capacitance film and aluminum electrolytic capacitors. Applications for the high-slew rate option include battery charging, photovoltaic emulation, power waveform generation, and medium speed power pulsing. These applications all benefit from higher bandwidth and in many cases, can tolerate increased ripple voltage.

For photovoltaic emulation applications, higher bandwidth and lower output capacitance enable improved performance with higher speed, maximum power tracker algorithms. Maximum power tracker circuitry deviates the operating point of photovoltaic arrays to determine maximum power output. Slow responding emulation sources can present a problem when the speed of the algorithm

exceeds that of the source. Furthermore, with lower output capacitance, changes in the operating point and transients, caused by shorting the solar inverter input, produce lower unwanted input currents.

The high-slew rate option enables the power supply to operate as a low frequency, power pulse generator. With the special capacitors selected for this option, it is possible to superimpose waveforms or produce a medium speed pulse on top of the dc output and expect normal capacitor life. It is important to note that the power supply output is single quadrant; that is, the output voltage or current cannot reverse.

The tables below define the High Slew Rate Output (+HS) option specifications.

Table 1.8. XR Series High Slew Rate Output Capacitance and Ripple

Output Voltage Range (Vdc)	Output Capacitance (uF)	Output Ripple (mVrms)
5	13200	500
10	4080	750
16	4080	750
20	2340	1000
32	2340	1500
40	240	1500
50	240	1750
80	240	1750
100	160	2000
125	160	2000
160	160	2500
200	160	2500
250	160	3000
375	160	3000
400	160	3000
500	56	3000
600	56	3500
800	56	3500
1000	52	3500
Note:		
1. For 20 to 30 kW models, multiply capacitance by 2		
2. For 45 kW models, multiply capacitance by 3.		
3. For 60 kW models, multiply capacitance by 4		
4. For 75 kW models, multiply capacitance by 5		

Table 1.9. TS Series and MS Series High Slew Rate Output Capacitance and Ripple

Output Voltage Range (Vdc)	Output Capacitance (uF)	Output Ripple (mVrms)
5	13200	750
8	9000	750
10	4080	750
16	4080	750
20	2340	1000
32	1170	1000
40	750	3500
50	750	3500
80	300	4000
100	200	4000
125	200	4500
160	200	4500
200	200	5000
250	200	5000
375	160	5500
400	160	5500
500	70	5500
600	60	6000
800	56	6000
1000	52	6000
1500	18	6500
2000	18	6500
3000	9	7000
4000	9	7000
Note:		
1. For 20 to 30 kW models, multiply capacitance by 2		
2. For 45 kW models, multiply capacitance by 3.		
3. For 60 kW models, multiply capacitance by 4		
4. For 75 kW models, multiply capacitance by 5		

Table 1.10. MT Series High Slew Rate Output Capacitance and Ripple

Output Voltage Range (Vdc)	Output Capacitance (uF)	Output Ripple (mVrms)
16	41000	1000
Note:		
1. For 500 kW models, multiply capacitance by 2		
2. For 750 kW models, multiply capacitance by 3		
3. For 1000 kW models, multiply capacitance by 4		

Output Voltage Range (Vdc)	Output Capacitance (uF)	Output Ripple (mVrms)
20	4100	1000
32	16000	1400
40	16000	1500
50	16000	1500
80	16000	1500
100	8000	1500
125	8000	1500
160	8000	1500
200	3650	1750
250	3650	1750
375	1450	2000
400	1450	2000
500	1450	2000
600	1450	2000
800	1280	2000
1000	1280	2000
1250	320	3500
1500	320	3500
2000	320	3500
3000	160	4000
4000	160	4000
Note:		
1. For 500 kW models, multiply capacitance by 2		
2. For 750 kW models, multiply capacitance by 3		
3. For 1000 kW models, multiply capacitance by 4		

1.6.3. IEEE-488 GPIB Interface (+GPIB)

The IEEE-488 GPIB interface, sometimes called the General Purpose Interface Bus (GPIB), is a general purpose digital interface system that can be used to transfer data between two or more devices. It is particularly well-uited for interconnecting computers and instruments. Some of its key features are:

- Up to 15 devices may be connected to one bus
- Total bus length may be up to 20 m and the distance between devices may be up to 2 m
- Communication is digital (as opposed to analog) and messages are sent one byte (8 bits) at a time
- Message transactions are hardware handshaked
- Data rates may be up to 1 Mbyte/sec

1.6.4. LXI TCP/IP Ethernet Interface (+LXI)

Certified to the LXI Standard (Class C), the TCP/IP Ethernet option includes an embedded web-server, allowing web browser power supply control and monitoring from virtually anywhere. LXI is an instrumentation platform based on industry standard Ethernet technology designed to provide modularity, flexibility, and performance to small- and medium-sized systems.

LXI's advantages are exemplified in its compact, flexible package providing high-speed I/O and reliable measurements. The Magna-Power Electronics LXI TCP/IP Ethernet option includes an embedded web-server, allowing web browser power supply control and monitoring from virtually anywhere.

1.6.5. UID47: Universal Interface Device (+UID)

Magna-Power Electronics UID47 is a general purpose device for connection to Magna-Power Electronics power supplies. The device contains the necessary circuitry for configuring power supplies for master/slave parallel or series operation.

Master/slave parallel operation allows two or more power supplies to equally share output current when connected together. Master/slave series operation allows two or more power supplies to equally share output voltage when connected together. In either operation mode, the master unit will command the slave units to the proper voltage and current. Each unit will display its own individual voltage and current. Installation requires setting jumpers, placing included 37-conductor cables between the UID47 and power supplies, and wiring the power supply outputs in either parallel or series.

The UID47 can be used as an interface for connecting control and monitoring lines to external circuitry. It also contains an area on the printed circuit board for interconnecting wires and placing components for specific user applications. The key features for the UID47 are as follows:

- Compatible with all Magna-Power Electronics power supplies
- Plug and play interface for series and parallel master/slave operation
- User configurable screw terminal connector
- Pad area for custom circuitry
- (2) 6-foot 37-pin cables included

1.6.6. USB Edgeport (+USB)

Edgeport USB-to-serial converters offer instant I/O expansion for peripheral device connectivity. An out-of-the-box (external) alternative to PCI cards, Edgeport makes it easy to add serial port to a PC, server or thin client in minutes without opening the chassis, reconfiguring or rebooting the system.

The USB Edgeport device plugs directly into the back of the power supply, creating a seamless USB interface. Feature-rich design, reliability and unmatched operating system support make Edgeport USB-to-serial converters ideal for mission-critical enterprise applications. An USB cable is included along with associated drivers on the Magna-Power Electronics software CD.

1.6.7. Water Cooling (+WC)

Water cooling is available for Magna-Power Electronics TS Series and MS Series power supplies. This option is typically used in corrosive environments, such as electroplating applications or in densely packaged system cabinets, where heat removal by air cooling presents a problem.

Water cooling is implemented with chill plates and an integrated central heat exchanger. The chill plates provides a thermal conduction path for heat sensitive components and the central heat exchanger removes heat from air internal to the enclosure. Water cooled TS Series models have enclosures without vent holes and are basically sealed the unit from the environment. An internal solenoid valve enables water flow when the chill plate reaches 60 degrees celcius. Operation of the solenoid prevents internal condensation.

5 kW to 15 kW models have a 1/4" NPT male inlet and outlet for water flow. Models greater than 15 kW have a 1/2" NPT male inlet and outlet for water flow with external plumbing that interconnects power supply modules. A minimum of 2.50" is recommended behind the enclosure for this hardware and user connections. For systems requiring more than one power supply, plumbing connections must be paralleled; that is, water should not flow from one power supply into another.

Installation

2.1. Product Inspection

Carefully unpack the power supply saving all packing materials and included enclosures. Inspect power supply for possible shipping damage. Check that there are no broken knobs or connectors, the external surface is not scratched or dented, the meter faces are not damaged, and all controls move freely. Any external damage may be an indication of internal damage.

The following parts are included with all models:

- XR Series III programmable DC power supply
- RS232 cable
- Rear metal cover with required fastening hardware
- Printed XR Series III user's manual
- CD with software, drivers, and digital documentation
- Calibration certificate with declaration of conformity

2.2. Rack Installation and Cooling

XR Series III power supplies are intended for rack mount installations only and are designed to fit in standard 19" equipment racks. Additional support, other than that provided by the front panel, is required. Angle slides or cross beam supports securely fastened to the rack are recommended for supporting the weight of the power supply. The unit should be horizontally mounted.

Caution: The power supply is too heavy for one person to safely lift and mount. To avoid injury, ask a co-worker for assistance.

Each programmable DC power supply is cooled by suitable fans exhausting warm air to the rear of the cabinet. Fresh air intake is from the sides of the cabinet allowing two or more XR Series III supplies to be stacked. Equipment racks should be equipped with fans or blowers to remove heat generated by the power supplies. The manufacturer recommends fresh air intake at the bottom of the cabinet and exhaust at the top. Cabinet fans and blowers should be rated at **300 CFM** for each XR Series III supply.

Caution: Blocking ventilation will cause the power supply to overheat.

2.3. AC Input Connections

Caution: Disconnect AC power from the mains before attempting any installation procedure.

Grounding: A safety ground wire must be connected to the unit as indicated by the protective ground symbol at the rear of the power supply.

AC power is wired to the power supply by attaching three cables plus ground for 3-phase installations and two cables and ground for single phase installations. The manufacture recommends cables, as specified in *Table 2.1, "Suggested Ampacities of Conductors as Recommended by the National Electrical Code"* or *Table 2.2, "Suggested Ampacities of 4-Conductor Type S or SO Cable"*, be crimped to ring terminals and securely fastened to the studs at the rear of the power supply. After connections are made, screw the four standoffs into the back panel and place the protective shield over the connections. This power supply is designed to be permanently connected to the power source requiring a readily accessible disconnect device incorporated into the fixed wiring.

Table 2.1. Suggested Ampacities of Conductors as Recommended by the National Electrical Code

	Temprature Rating of Copper Conductor			
	60 °C	75 °C	85 °C	90 °C
	Types	Types	Types	Types
Wire Size (AWG)	RUW, T, TW	FEPW, RH, RH, RUH, THW, THWN, XHHW, ZW	V, MI	TA, TBS, SA, AVB, SIS, FEP, FEPB, RHH, THHN, XHHW
14	25	30	30	35
12	30	35	40	40
10	40	50	55	55
8	60	70	75	80
6	80	95	100	105
4	105	125	135	140
3	120	145	160	165
2	140	170	185	190
1	165	195	215	220
1/0	195	230	250	260
2/0	225	265	290	300
3/0	260	310	335	350
4/0	300	360	390	405
250 MCM	340	405	440	455
300 MCM	375	445	485	505
350 MCM	420	505	550	570

Table 2.2. Suggested Ampacities of 4-Conductor Type S or SO Cable

Wire Size (AWG)	Maximum Current (A)
18	7
16	10
14	15
12	20
10	25
8	35
6	45
4	60

Wire Size (AWG)	Maximum Current (A)
2	80

2.4. DC Output Connections

Caution: Disconnect AC power from the mains before attempting any installation procedure.

DC power is wired to the power supply by attaching two cables to the output bus bars. Magna-Power Electronics recommends cables, as specified in *Table 2.1, "Suggested Ampacities of Conductors as Recommended by the National Electrical Code"* or *Table 2.3, "Suggested Ampacities of Welding Cable"*, be crimped to ring terminals and securely fastened to bus bars using 3/8" bolts, washers, and lock washers. The bus bars contain 3/8"-16 threaded inserts. After connections are made, screw the four standoffs into the back panel and place the protective shield over the connections.

Caution: Make sure connections are tight to avoid overheating of the bus bars.

Table 2.3. Suggested Ampacities of Welding Cable

Wire Size (AWG)	Maximum Current (A)
6	85
4	110
3	130
2	150
1	170
1/0	200
2/0	235
3/0	275
4/0	315
*	315+

* Contact factory for assistance

2.4.1. Remote Voltage Sensing

Remote sensing is used to improve the degradation of regulation which will occur at the load when the voltage drop in the connecting wires is appreciable. Compensation is achieved by configuring the power supply for remote sensing as described in *Figure 3.4, "Enable or disable remote sense functionality"*. Using a pair of #20 AWG wires, connect terminal 2 of JS2 to the positive terminal of the load and connect terminal 1 of JS2 to the negative terminal of the load. *Table 2.4, "Remote Sense (JS2) Terminal Definition"* defines the remote sensing pins and *Figure 2.1, "(a) Local and (b) remote sensing"* illustrates standard output sensing and remote output sensing.

Table 2.4. Remote Sense (JS2) Terminal Definition

Pin	Definition
1	VO1REM-

Pin	Definition
2	VO1REM+

Caution: Switching remote sense leads or disconnecting remote sense leads while the output is enabled can cause device failure. Only switch or disconnect remote sense leads while the power supply is in standby or turned off.

Enabling remote sense activates the remote sense lead detector. The remote sense lead detector checks that the remote sense leads have been connected to the load. With the power supply configured for remote sensing and upon enabling power output, the sense location is initially set to local. The sense location is switched to remote upon reaching 7.5% of full scale output voltage. If the voltage detected is greater than 4.5% of full scale output voltage, the sense location remains remote; if the output voltage detected is less than 4.5%, then the sense location will automatically revert back to local.

The remote sense indicator on the front panel will flash when the remote sense functionality has been enabled, but the power supply is remaining in local sense. The power supply will remain in local sense with the REM SEN light flashing if the output voltage never exceeds 7.5% of full scale output voltage or the remote sense lead detector has determined sense leads are not connected. The remote sense indicator will remain flashing until the remote sense detector has detected the presence of remote sense voltage within the limits described above.

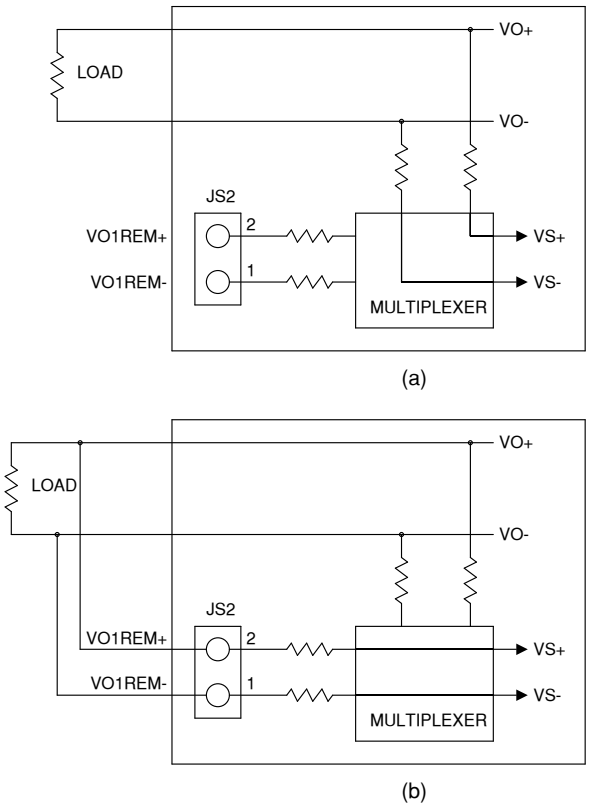

Figure 2.1. (a) Local and (b) remote sensing

2.5. Electrical Check

This section describes the electrical checkout procedure for the XR Series III. For XR Series III units purchased with the standard XR Version front panel, refer to *Section 2.5.1, "Electrical Check for Models with XR Version Front Panel"*. For XR Series III purchased with the C Version front panel, refer to *Section 2.5.2, "Electrical Check for Models with C Version Front Panel"*.

2.5.1. Electrical Check for Models with XR Version Front Panel

With the power supply off, disconnect the load, set voltage and current potentiometer controls fully counterclockwise, and set the over voltage trip and over current trip settings to maximum. Connect the power supply to a suitable source of AC voltage. For this test, only 50% of rated AC current is required. Turn the power switch on and observe the indicator lights going through the startup routine. After initialization, the following indicator lights should be on: STANDBY, INT CTL, EXT CTL, and ROTARY. This is the default configuration from the factory. It is recommended that the following brief electrical check be made shortly after unpacking the supply.

Press the start switch and advance the current control one turn clockwise. The power and voltage control indicators should light. Increase the voltage set point to maximum and then to minimum. DC voltage should increase smoothly from minimum to maximum to minimum as indicated on the meter. Return the voltage control full counterclockwise. Press the stop switch.

To check over voltage trip, press the menu key. This places the power supply in data entry mode to set over voltage trip. Using the up/down arrow keys, enter an over voltage trip set point at half the rating of the power supply. Once the over voltage trip set point has been entered, press the enter key to save the information.

Press the start switch and slowly increase the voltage set point. Over voltage trip should operate at the over voltage trip set point. The over voltage trip (OVT) indicator should turn on, the power and voltage control indicators should turn off, and the supply should shut down. Press the clear key. Now set the over voltage trip set point to maximum which is 110% the full scale rating of the power supply. Again start the supply and observe that the power supply operates normally.

With the main power disconnected, connect a short to the power output terminals on the rear panel. Reconnect the main power, set voltage and current controls full counterclockwise, and turn the power switch on.

Press the start switch and advance the voltage control one turn clockwise. Increase the current set point to maximum and then to minimum. The power and current control indicators should light. DC current should increase smoothly from minimum to maximum to minimum as indicated on the meter. Return the current control full counterclockwise. Press the stop switch.

To check over current trip, press the menu key and the item key one time. This places the power supply in data entry mode to set over current trip. Using the up/down arrow keys, enter an over current trip set point at half the rating of the power supply. Once the over current trip set point has been entered, press the enter key to save the information.

Press the start switch and slowly increase the current set point. Over current trip should operate at the over current trip set point. The over current trip (OCT) indicator should turn on, the power and current control indicators should turn off, and the supply should shut down. Press the clear key. Now set the over current trip set point to maximum which is 110% the full scale rating of the power supply. Again start the supply and observe that the power supply operates normally.

If any of these events do not occur, the supply is defective and should not be operated. Depending on the circumstances, either warranty service or trouble shooting is required.

2.5.2. Electrical Check for Models with C Version Front Panel

The electrical check for XR Series III products with the C Version front panel models require use of the Remote Interface Software described in Section 5.0. With the software installed and the power supply connected to the desired communications interface, select XR Version in the Configuration Setup Panel. Select the Virtual Control Panel in the View Menu to display the XR Version front panel. Follow the procedure outlined in *Section 2.5.1, “Electrical Check for Models with XR Version Front Panel”* using the Virtual Control Panel from within the Remote Interface Software.

Operation

XR Series III power supplies are normally shipped with its configuration set for rotary mode (front panel) input, local sensing, internal control, and external control. This configuration is set by front panel commands described in *Section 3.2.3, "Configuration Commands"* or by software. With this configuration, the unit can operate in either constant voltage or a constant current output using the front panel controls. XR Series III power supplies with the C Version front panel are configured for external control and remote, enabling RS232, IEEE-488 GPIB (+GPIB), LXI TCP/IP Ethernet (+LXI), or Edgeport USB (+USB) communications. The front panel voltage and current controls set the boundary limits for output voltage and current, respectively. The impedance of the load determines whether the unit is voltage or current controlled and the illumination of the respective mode indicator lights indicate the state. The power supply will make a seamless autocrossover from voltage mode to current mode control, as warranted by the set-points and/or load impedance. If either control is set to maximum counter clockwise rotation, the other control will have little or no effect, forcing either a zero voltage-limit or zero current-limit.

3.1. Output Regulation Modes

3.1.1. Constant Voltage

To select constant voltage output, proceed as follows:

With the supply off, set both rotary controls fully counterclockwise. Press the V/I DIS key and advance the voltage and current controls for the desired output voltage and the desired crossover current. The crossover current is the current at which the power supply becomes a constant current source.

Connect the load and turn on the power supply. The output voltage should be close to the voltage set point. If a load change causes the current limit to be exceeded, the power supply will automatically crossover to constant current output at the preset current limit setting and the output voltage will drop proportionately. In setting the current limit, allowance must be made for high peak currents which can cause unwanted crossover.

3.1.2. Constant Current

To select constant current output, proceed as follows:

With the supply off, set both rotary controls fully counterclockwise. Press the V/I DIS key and advance the voltage and current controls for the desired output current and the desired crossover voltage. The crossover voltage is the voltage at which the power supply becomes a constant voltage source.

Connect the load and turn on the power supply. The output current should be close to the current set point. If a load change causes the voltage limit to be exceeded, the power supply will automatically crossover to constant voltage output at the preset voltage limit setting and the output current will drop proportionately.

3.1.3. Pulse Loading

The power supply will automatically crossover from constant voltage to constant current operation, or the reverse, in response to an increase (over the preset limit) in the output current or voltage, respectively. With the preset limit set to the average output current or voltage, high peak currents or voltages, as occur in pulse loading, may exceed the preset limit conditions and cause crossover to occur. To avoid this unwanted crossover, the preset limit settings must be set for the peak requirement and not the average.

There are internal capacitors across the output terminals of the power supply. These capacitors help to supply high-current pulses of short duration during constant voltage operation. Any capacitance added externally will improve the pulse current capability, but will decrease the safety provided by the constant current circuit. A high-current pulse may damage load components before the average output current is large enough to cause the constant current circuit to operate.

3.2. Front Panel Commands

As shipped, the XR Series III power supply is configured for local sensing, rotary control, internal programming, and voltage input as specified on the rear serial label. XRC Series III power supplies cannot be controlled through the front panel other than on/off. The front panel voltage and current controls set the boundary limits for output voltage and current, respectively. The following sections describe how to use all of the front panel features. Front panel commands are broken into four groups: run mode commands, set point commands, configuration commands, and calibration commands.

Run mode commands, *Section 3.2.1, "Run Mode Commands"*, are used when the power supply has been configured for the desired application and the desired set points have been programmed into memory.

Set point commands, *Section 3.2.2, "Set Point Commands"*, include voltage set, current set, over voltage trip set, and over current trip set. All of these commands can be made when the power supply is in either the standby, alarm, or power mode state.

Configuration commands, *Section 3.2.3, "Configuration Commands"*, include local or remote sense, internal and/or external control, remote interlock, and mode of set point input. There are three choices for set point inputs: rotary or front panel potentiometers, external analog signals through connector JS1, and remote computer communications: RS232 through connector JS3, optional IEEE-488 through connector JS4, and optional LXI TCP/IP Ethernet through JS5. Changes in configuration commands are only allowed when the power supply is in the standby or alarm state.

Calibration commands, *Section 3.2.4, "Calibration Commands"*, enable programming of internal digital potentiometers. The digital potentiometers are used for calibrating the voltage reference and feedback amplifiers. Calibration commands can be made when the power supply is in either the standby, alarm, or power mode state.

Front panel programming commands are illustrated with programming charts. This method of presentation maps the path to key commands, describes front panel indicators as a result of key presses, and illustrates anticipated results.

3.2.1. Run Mode Commands

Figure 3.1, "Run Mode Commands" illustrates run mode commands. Run mode commands are used when the power supply has been configured for the desired application.

Pressing the START switch places the power supply in a power state. The starting sequence consists of energizing the step start and main contactors followed by enabling of the power processing stages. Once enabled, output voltage and current increase to the set points established by the front panel, external analog control, or computer controlled remote communications.

Pressing the stop switch places the power supply in a standby state. The power processing stages are disabled and the step start and main contactors are denergized.

The V/I DIS key displays the voltage and current set points on the voltage and current display, respectively. The display reverts to displaying the actual output voltage and output current when the V/I DIS key is released. If the power supply is operating in voltage mode, then the actual output voltage will be close to the voltage set point and the actual output current will be less than the current set

point. If the power supply is operating in current mode, then the actual output current will be close to the current set point and the actual output voltage will be less than the voltage set point.

The TRIP DIS key displays over voltage trip and over current trip on the voltage and current display, respectively. The display reverts to displaying the actual output voltage and output current when the V/I DIS key is released.

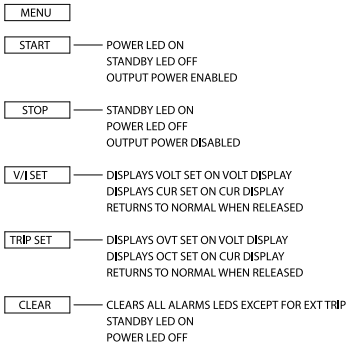

Figure 3.1. Run Mode Commands

3.2.2. Set Point Commands

With the power supply configured for rotary input, voltage and current set point commands are entered with the front panel potentiometers and over voltage trip and over current trip are entered with the up/down arrow keys.

To set over voltage trip or over current trip, press the MENU key. The OVT (over voltage trip) LED will initially flash. This indicates that an up/down entry will create a new OVT set point. Pressing the item key causes the OCT (over current trip) LED to flash indicating that an up/down entry will create a new OCT set point. After the change is made, the enter key must be pressed to save the new set point or the clear key can be pressed to exit without saving the new set point.

In all control modes, set point voltage and current can be quickly displayed by simply pressing the V/I dis key. Similarly, set points for OVT and OCT can be displayed by pressing the trip dis key.

The up/down keys have an acceleration feature to speed up entries. Pressing and holding the up/down keys cause number changes to increase or decreases at a faster rate. Upon nearing the desired set point number, release and press again to slow down the rate of change.

Pressing and holding the clear key for 5 seconds while programming set point commands sets the OVT and OCT to default values.

Front panel menu walthroughs for setting protective voltage and current trip levels are illustrated by *Figure 3.2, “Set over voltage trip”* and *Figure 3.3, “Set over current trip”*. These commands can be made when the power supply is in either the standby, alarm, or power mode states.

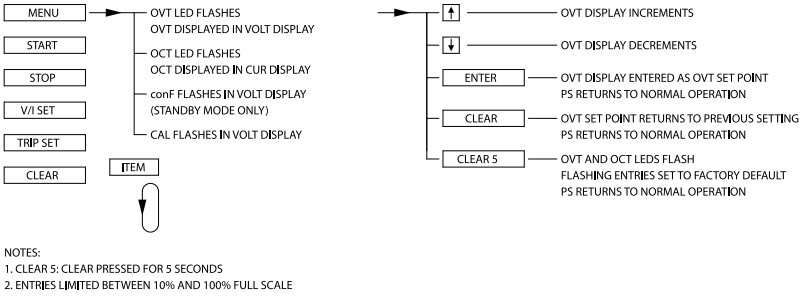

Figure 3.2. Set over voltage trip

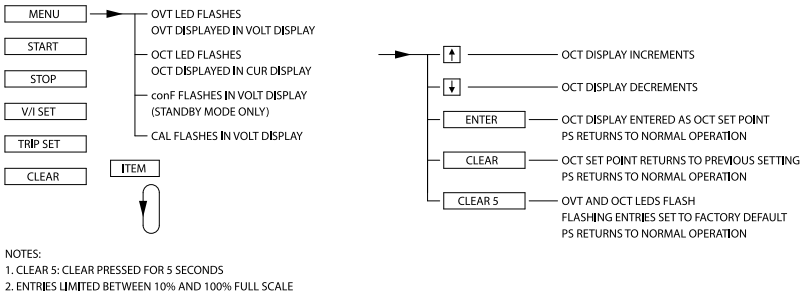

Figure 3.3. Set over current trip

3.2.3. Configuration Commands

To enter the configuration commands, first press the MENU key. The over voltage trip LED will initially flash. Then press the item key 2 times. The voltage display will flash conF (configure). Press the enter key to select configure commands. The REM SEN (remote sense) LED will initially flash. To choose remote sense, press the enter key or to select other configuration commands, press the item key. Each press of the item key will cause the another LED to flash. The order is REM SEN (remote sense) illustrated by *Figure 3.4, "Enable or disable remote sense functionality"*, INT CTL (internal control, local START/STOP/CLEAR/ARM functions) illustrated by *Figure 3.5, "Enable or disable internal control mode"*, EXT CTL (external control, external START/STOP/CLEAR/ARM functions) illustrated by *Figure 3.6, "Enable or disable external control mode"*, ROTARY illustrated by *Figure 3.7, "Enable or disable rotary input mode"*, EXT PGM (external program) illustrated by *Figure 3.8, "Enable or disable external program input mode"*, REMOTE illustrated by *Figure 3.9, "Enable or disable computer input mode"*, and LOC (interlock) illustrated by *Figure 3.10, "Enable or disable external interlock functionality"*. Further item key presses will cycle the menu back to the beginning item, REM SEN. All of these commands must be made when the power supply is in the standby or alarm mode state. In addition, all of the configuration commands can be made from software using SCPI commands.

Remote sense, internal control, external control, and interlock can be selected or deselected when the REM SEN, INT CTL, EXT CTL, and LOC LED is flashing. To select, press enter or to deselect, press clear. Remote sense allows the output voltage to be sensed at the load rather than at the output terminals of the power supply. This feature eliminates regulation degradation caused by the voltage drop across the output cables. Details on the physical connections are covered in Section 3.3.

Internal control enables the START, STOP, and CLEAR keys on the front panel. External control enables the start, stop, and clear inputs at terminals 17, 19, and 18 of connector JS1 on the rear panel, respectively. Both internal control and external control may be enabled to allow simultaneous control. Interlock requires a physical short between terminals 26 and 37 of connector JS1 to enable operation. This feature is useful for process control applications when a safety interlock is required. For wiring details, refer to *Section 3.3.4, "Digital Input Lines"*.

Configuration commands for rotary, external program, and remote sets the reference input mode for voltage set, current set, over voltage trip, and over current trip. Only one input mode may be selected. Pressing enter when one of the respective LED is flashing causes that mode to selected and disables the previously selected mode. Pressing clear when the respective LED is flashing allows the user to exit the command sequence without change. With rotary control, voltage set points and current set points are set by the front panel potentiometers. By selecting external program, all reference inputs are set with the analog inputs at terminals 3, 22, 4, and 23 of connector JS1. See *Section 3.3, "External 37-pin (JS1) I/O Programming and Operation"*, for connecting external reference inputs. By selecting REMOTE, all reference inputs are set over the RS232, optional IEEE-488 GPIB, or LXI TCP/IP Ethernet.

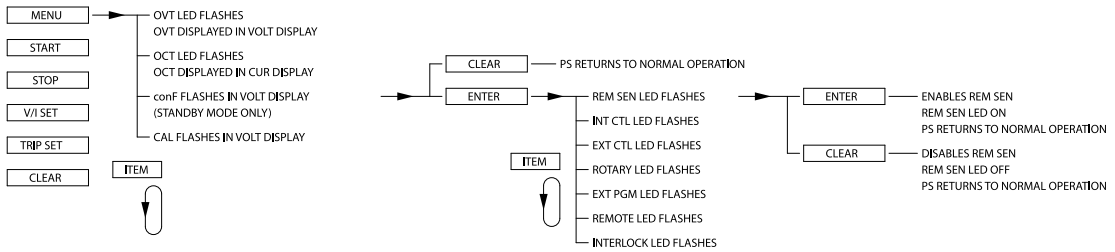

Figure 3.4. Enable or disable remote sense functionality

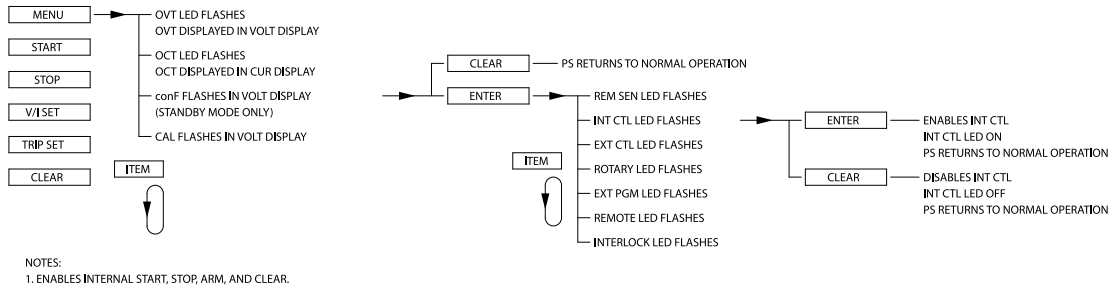

Figure 3.5. Enable or disable internal control mode

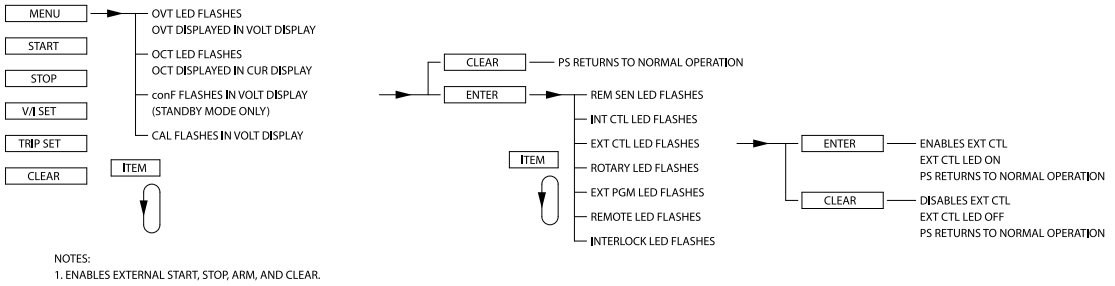

Figure 3.6. Enable or disable external control mode

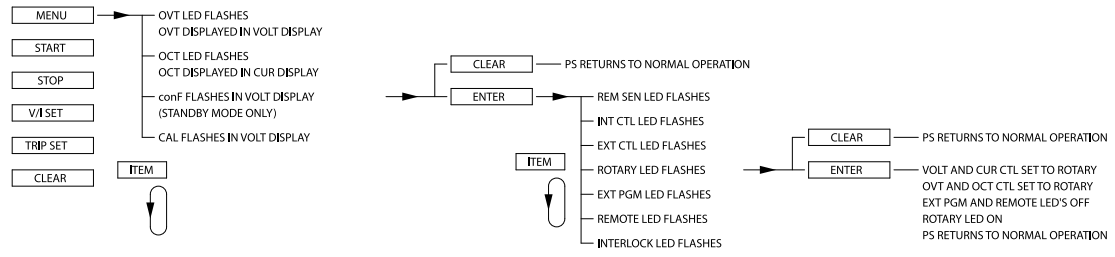

Figure 3.7. Enable or disable rotary input mode

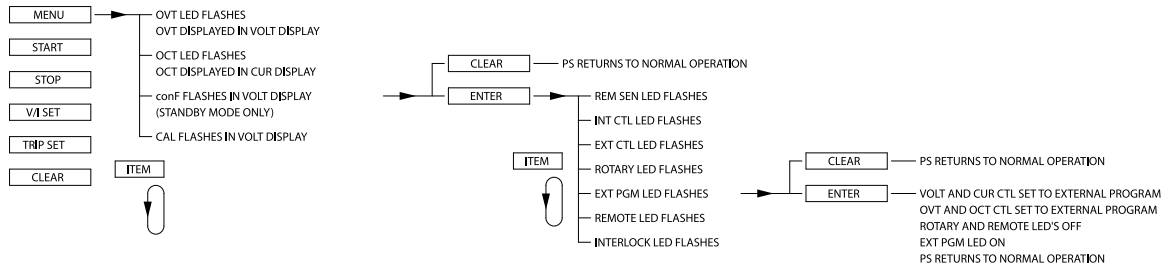

Figure 3.8. Enable or disable external program input mode

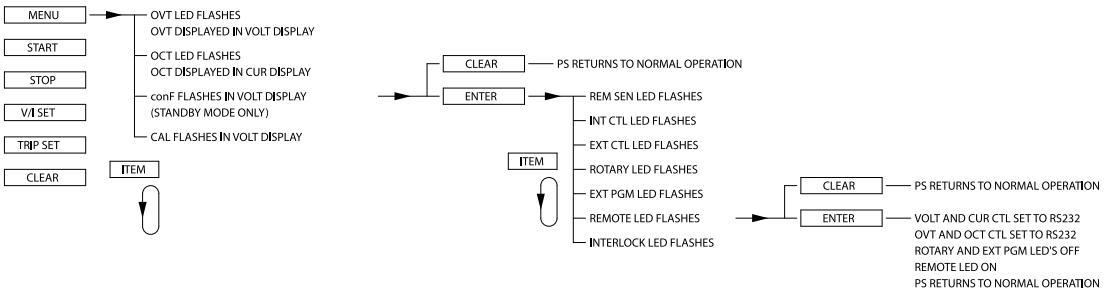

Figure 3.9. Enable or disable computer input mode

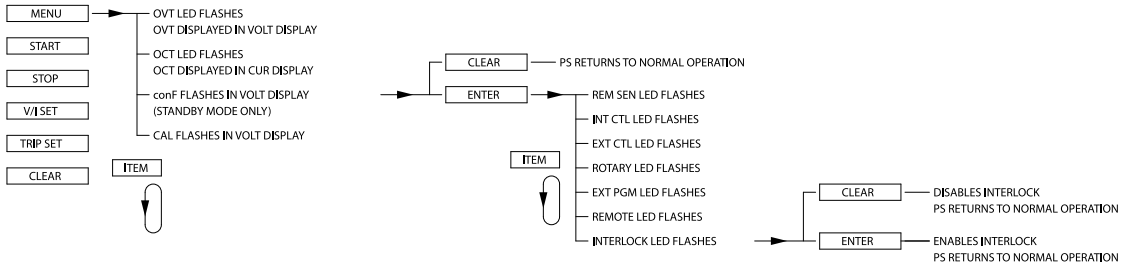

Figure 3.10. Enable or disable external interlock functionality

3.2.4. Calibration Commands

Figure 3.11, "Front panel calibration menu" illustrates how to utilize the calibration commands using the front panel. Calibration commands allow calibration of five digital potentiometers, display of the firmware and hardware revisions, and reset the digital potentiometers to the factory calibration settings. All of these commands can be made when the power supply is in either the standby or power mode state.

To enter the calibration commands, first press the menu key. The over voltage trip LED will initially flash. Then press the item key 3 times. The voltage display will flash CAL (calibration). Press enter for 10 seconds or press clear to exit the calibration command menu. Upon entering the calibration commands, the output voltage will be displayed in the voltage display, the potentiometer setting, 0 to 255, will be displayed in the right three digits of the current display, and P and 1 will alternately flash in the left digit of the current display. Potentiometer 1 adjusts the gain of the voltage feedback amplifier, potentiometer 2 adjusts the input offset voltage of the voltage feedback amplifier, potentiometer 3 adjusts the gain of the current feedback amplifier, potentiometer 4 adjusts the input offset voltage of the current feedback amplifier, and potentiometer 5 adjusts the gain of the reference which is used for the digital to analog and analog to digital converters.

Pressing the item key advances control to potentiometer 2. The left digit of the current display will alternately flash P and 2, the output voltage will be displayed in the voltage display, and the potentiometer setting, 0 to 255, will be displayed in the right three digits of the current display.

Pressing the item key again will advance the control to potentiometer 3. Now the output current will be displayed in the current display, the potentiometer setting, 0 to 255, will be displayed in the right three digits of the voltage display, and the left digit of the voltage display will alternately flash P and 3.

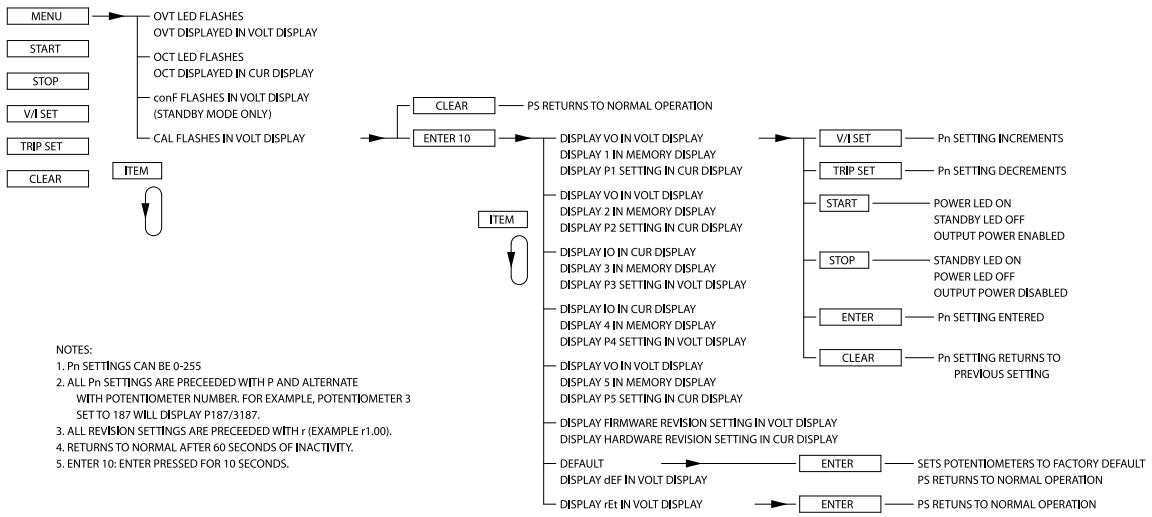
MENU
START
STOP
V/I SET
TRIP SET
CLEAR
ITEM
OVT LED FLASHES
OVT DISPLAYED IN VOLT DISPLAY
OCT LED FLASHES
OCT DISPLAYED IN CUR DISPLAY
conF FLASHES IN VOLT DISPLAY
(STANDBY MODE ONLY)
CAL FLASHES IN VOLT DISPLAY
CLEAR
PS RETURNS TO NORMAL OPERATION
ENTER 10
DISPLAY VO IN VOLT DISPLAY
DISPLAY 1 IN MEMORY DISPLAY
DISPLAY P1 SETTING IN CUR DISPLAY
DISPLAY VO IN VOLT DISPLAY
DISPLAY 2 IN MEMORY DISPLAY
DISPLAY P2 SETTING IN CUR DISPLAY
DISPLAY IO IN CUR DISPLAY
DISPLAY 3 IN MEMORY DISPLAY
DISPLAY P3 SETTING IN VOLT DISPLAY
DISPLAY IO IN CUR DISPLAY
DISPLAY 4 IN MEMORY DISPLAY
DISPLAY P4 SETTING IN VOLT DISPLAY
DISPLAY VO IN VOLT DISPLAY
DISPLAY 5 IN MEMORY DISPLAY
DISPLAY P5 SETTING IN CUR DISPLAY
DISPLAY FIRMWARE REVISION SETTING IN VOLT DISPLAY
DISPLAY HARDWARE REVISION SETTING IN CUR DISPLAY
DEFAULT
DISPLAY dEF IN VOLT DISPLAY
DISPLAY rEt IN VOLT DISPLAY
V/I SET
Pn SETTING INCREMENTS
TRIP SET
Pn SETTING DECREMENTS
START
POWER LED ON
STANDBY LED OFF
OUTPUT POWER ENABLED
STOP
STANDBY LED ON
POWER LED OFF
OUTPUT POWER DISABLED
ENTER
Pn SETTING ENTERED
CLEAR
Pn SETTING RETURNS TO
PREVIOUS SETTING
ENTER
SETS POTENTIOMETERS TO FACTORY DEFAULT
PS RETURNS TO NORMAL OPERATION
ENTER
PS RETUNS TO NORMAL OPERATION
NOTES:
1. Pn SETTINGS CAN BE 0-255
2. ALL Pn SETTINGS ARE PRECEEDED WITH P AND ALTERNATE
WITH POTENTIOMETER NUMBER. FOR EXAMPLE, POTENTIOMETER 3
SET TO 187 WILL DISPLAY P187/3187.
3. ALL REVISION SETTINGS ARE PRECEEDED WITH r (EXAMPLE r1.00).
4. RETURNS TO NORMAL AFTER 60 SECONDS OF INACTIVITY.
5. ENTER 10: ENTER PRESSED FOR 10 SECONDS.

Figure 3.11. Front panel calibration menu

Press the item key again will advance to control potentiometer 4. The left digit of the voltage display will alternately flash P and 4, the output current will be displayed in the current display, and potentiometer, 0 to 255, will be displayed in the right three digits of the voltage display.

To advance adjustment to potentiometer 5, press the item key again. The left digit of the current display will alternately flash P and 5, the output voltage will be displayed in the voltage display, and the potentiometer setting, 0 to 255, will be displayed in the right three digits of the current display.

Once a digital potentiometer has been selected for adjustment, pressing the up/down keys increments or decrements the potentiometer setting, respectively. To save the new setting, press the enter key or press the clear key to exit the routine. Instructions for the calibration procedure are discussed in Section 7.3.1.

After selecting digital potentiometer 5, pressing the item key displays the firmware revision in the voltage display and the hardware revision in the current display. Pressing the item key again displays dEF (default) in the voltage display. Pressing the enter key resets the five digital potentiometers to the factory default settings.

To exit the calibration menu, press the item key until rEt (return) appears in the voltage display. Press the enter key to exit the calibration menu.

3.3. External 37-pin (JS1) I/O Programming and Operation

All Magna-Power Electronics programmable DC power supplies come standard with 37-pin isolated analog and digital control, which maps nearly all available monitoring and programming functions in a standard DB-37 connector arrangement. The 37-pin connector, labeled JS1 and defined in *Table 3.1, "External 37-pin (JS1) I/O Terminal Definition"* is located on the rear of the power supply. To use external programming, there are three initial setup requirements:

1. Configure the power supply for external programming mode. This programming mode is enabled when EXT PGM is illuminated on the front panel, allowing the power supply to receive voltage and current set points from an analog voltage. Refer to *Section 3.2.3, "Configuration Commands"* for configuration from the front panel or *Chapter 5, Computer Programming* for configuration using software. Programming mode settings are retained after power down.

2. Configure the power supply for external control. This control mode is enabled when EXT CTL is illuminated on the front panel, allowing the power supply to receive start, stop, and clear

commands from an external digital signal. Refer to *Section 3.2.1, "Run Mode Commands"* for configuration from the front panel or *Chapter 5, Computer Programming* for configuration using software. Programming mode settings are retained after power down.

3. All analog pins must have a non-zero reference voltage applied for the unit to operate properly. Ensure that VREF EXT (Pin 3), TVREF EXT (Pin 4), IREF EXT (Pin 22), and TIREF EXT (Pin 23) are all set to a non-zero voltage. In most applications, three of the four analog input references are jumpered to the +10V REF (Pin 21) with the user supplied external reference signal used for the remaining signal.

Table 3.1. External 37-pin (JS1) I/O Terminal Definition

Pin	Definition	Pin	Definition	Pin	Definition
1	REF GND	14	EXT CTL	27	PGM LINE
2	REF GND	15	FUSE	28	STANDBY
3	VREF EXT	16	ISO	29	PHASE LOSS
4	TVREF EXT	17	START	30	VOLT CTL
5	VO2	18	CLEAR	31	CONTROL
6	+2.5V REF CAL	19	STOP	32	OCT
7	GND	20	REF GND	33	INT CTL
8	POWER	21	+10V REF	35	ISI
9	THERMAL	22	IREF EXT	36	ARM
10	INTERLOCK	23	TIREF EXT	37	INTERLOCK SET
11	CUR CTL	24	IO2		
12	STANDBY/ALM	25	VMOD		
13	ALM	26	+5V REF		

3.3.1. External 37-pin I/O Pin Definitions

This section provides definitions for all the available pins on the External 37-pin JS1 Connector, split into their respective categories based on functionality.

References and Grounds

REF GND (Pin 1, 2, 20)
: Reference ground

+2.5V REF CAL (Pin 6)
: +2.5 Vdc reference voltage used for calibration purposes.

GND (Pin 7)
: Earth ground.

+10V REF (Pin 21)
: 10.0 V reference supply, relative to the REF GND pins. Reference capable of supplying a maximum of 25 mA. This pin is typically used as a reference to fix analog input pins to a desired value.

+5V REF (Pin 26)
: 5.0 V reference supply, relative to the REF GND pins. Reference capable of supplying a maximum of 25 mA.

ISO (Pin 16), CONTROL (Pin 31), ISI (Pin 35)
: Control references used for master/slaving only.

Analog Programming (Input)

The analog programming pins operate on a 0-10 Vdc scale with an input impedance of 10 kΩ.

VREF EXT (Pin 3)
: External voltage set point reference, 0-10 Vdc, proportional to the power supply output voltage. 0 Vdc on VREF EXT is equivalent to 0 Vdc output voltage, and 10 Vdc is equivalent to 100% full scale output voltage.

TVREF EXT (Pin 4)
: External over voltage trip set point reference, 0-10 Vdc, proportional to the power supply output voltage. 0 Vdc on TVREF EXT is equivalent to 0 Vdc trip reference, and 10 Vdc is equivalent to 110% full scale voltage over voltage trip.

IREF EXT (Pin 22)
: External current set point reference, 0-10 Vdc, proportional to the power supply output current. 0 Vdc on IREF EXT is equivalent to 0 Adc output current, and 10 Vdc is equivalent to 100% full scale output current.

TIREF EXT (Pin 23)
: External over current trip set point reference, 0-10 Vdc, proportional to the power supply output current. 0 Vdc on TIREF EXT is equivalent to 0 Adc trip reference, and 10 Vdc is equivalent to 110% full scale current over voltage trip.

VMOD (Pin 25)
: Modulation voltage input for non-linear profile emulation or voltage/current addition, subtraction, or multiplication factors. Function available on the SL Series and XR Series products, as well as units from the TS Series, MS Series, and MT Series with the D Version front panel.

Analog Monitoring (Output)

The analog monitoring pins operate on a 0-10 V scale with an 100 Ω output impedance.

VO2 (Pin 5)
: Instantaneous output voltage reference, 0-10 Vdc, proportional to the power supply output voltage. 0 Vdc on VO2 is equivalent to 0 Vdc output voltage and 10 Vdc is equivalent to 100% full scale output voltage.

IO2 (Pin 24)
: Instantaneous output current reference, 0-10 Vdc, proportional to the power supply output current. 0 Vdc on IO2 is equivalent to 0 Vdc output current and 10 Vdc is equivalent to 100% full scale output current.

Digital Programming (Input)

The digital programming pins are triggered by a 5.0 V signal with a 10 kΩ input impedance.

START (Pin 17)
: Enables the power supply output. The input contactors are engaged and the power supply will ramp up to the programmed set points

CLEAR (Pin 18)
: Clears a fault condition, returning the power supply to standby.

STOP (Pin 19)
: Disables the power supply output. The input contactors are disengaged and the power supply will ramp down to zero voltage and current.

ARM (Pin 36)
: Activates autosequencing through memory states. Function only available on the D Version front panel for TS Series, MS Series, and MT Series products.

INTERLOCK SET (Pin 37)
: +5 Vdc input for interlock signal. If the power supply output is enabled, and the +5 Vdc signal is removed, the power supply will enter into LOC fault condition, and the AC contactors will disengage. The fault will need to be cleared before re-enabling the output. Interlock must be enabled to use this functionality.

Digital Monitoring (Output)

The digital output pins are indicated by +5 Vdc signal for high (active), and a 0 Vdc signal for low (inactive). Faults are cleared via CLEAR (Pin 18). The digital programming pins operate with a 5 mA drive capacity per line.

POWER (Pin 8)
: Indication that the power supply output is enabled.

THERMAL (Pin 9)
: Indication that the input power processing devices or output rectifiers have reached a critical temperature. A resetting thermal breaker will reset upon cooling.

INTERLOCK (Pin 10)
: Indication that the power supply reached a interlock fault condition. This pin will stay active until 5.0 V is restored to INTERLOCK SET (Pin 37) and the fault is cleared. To restart the supply after the fault has been cleared, simply press the start switch.

CUR CTL (Pin 11)
: Indication that the power supply is operating in current-mode control.

STANDBY/ALM (Pin 12)
: Indication that the power supply is in standby or alarm condition. In both states, the output is disengaged.

ALM (Pin 13)
: Indication that the power supply is in alarm condition resulting from a fault. The alarm will need to be cleared before re-enabling the output.

EXT CTL (Pin 14)
: Indication that external start, stop, and clear is activated for use.

FUSE (Pin 15)
: Indication that the fuse alarm is activated. In units where circuit breakers are present, in place of fuses, an open circuit breaker connection will trigger the fuse alarm. Fuse alarm is only applicable in TS Series, MS Series, and MT Series power supplies.

PGM LINE (Pin 27)
: Indication that the voltage set point, current set point, over voltage trip, or over current trip external input is set beyond the range of control (greater than 12.50 V). These lines are constantly monitored and if any of these references are set above the normal bounds, program line diagnostics will disable the supply.

STANDBY (Pin 28)

Indication that the control circuits are powered, but the supply is disabled through the AC contactor. This is the power supply's normal off condition. To start the supply, press the start switch. To place the supply in standby, press the stop switch.

PHASE LOSS (Pin 29)

Indication that there's a problem with the power mains voltage. Phase loss alarm is only applicable in XR Series, TS Series, MS Series, and MT Series power supplies.

VOLT CTL (Pin 30)

Indication that the power supply is operating in voltage-mode control.

OCT (Pin 32)

Indication that the supply has exceeded the over current trip reference. This condition causes the supply to shutdown into a fault state. To clear this condition, the user must press the clear button on the front panel with internal control enabled or by applying 5.0 V to CLEAR (Pin 18) of JS1 with external control enabled. To restart the supply after the fault has been cleared, simply press the start switch.

A secondary over current trip diagnostic provides protection of internal circuitry due to abnormal line and load conditions or due to failed internal circuitry. This over current trip condition requires the control power to be recycled by toggling the power switch off and on.

INT CTL (Pin 33)

Indication that front panel start, stop, and clear is activated for use.

OVT (Pin 34)

Indication that the supply has exceeded the over voltage trip reference. This condition causes the supply to shutdown into a fault state. To clear this condition, the user must press the clear button on the front panel with internal control enabled or by applying 5.0 V to CLEAR (Pin 18) of JS1 with external control enabled. To restart the supply after the fault has been cleared, simply press the start switch.

3.3.2. External Analog Programming

XR Series III programmable DC power supply allow voltage, current, over voltage trip, and over current trip to be programmed from a external location. Programming can be accomplished by voltage, current, or resistive programming circuits.

Figure 3.12, "External (a) resistive, (b) voltage, and (c) current programming" illustrates the three alternative sources for programming the voltage set point. Similar methods apply to programming set point current, over voltage trip, and over current trip.

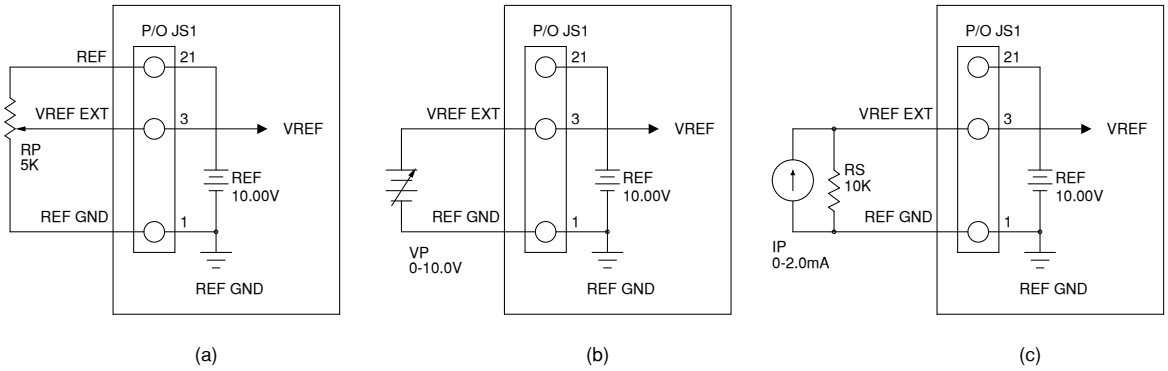

Figure 3.12. External (a) resistive, (b) voltage, and (c) current programming

Table 3.2. External Programming Parameters

Term	Parm	Description	Input Range (V)	Output Range
3	VREF EXT	Voltage Set	0-10.0	0-100% FS Voltage
22	IREF EXT	Current Set	0-10.0	0-100% FS Current
4	TVREF EXT	Over Voltage Tip Set	0-10.0	0-110% FS Voltage
23	TIREF EXT	Over Current Trip Set	0-10.0	0-110% FS Current

Note

If the applied analog input voltage exceeds 12.50 V, the PGL (program line) diagnostic LED alarm will light and the power supply will enter into standby mode.

3.3.2.1. External Voltage Source Programming

For programming using a voltage source, an external 10.0 V voltage source is placed between VREF EXT (Pin 3) and REF GND (Pin 1) of JS1 to control the output voltage.

The current set point, over voltage trip, and over current trip can be programmed in the same manner. Referring to the *Section 3.3.1, "External 37-pin I/O Pin Definitions"* for terminal identification, use IREF EXT (Pin 22) to program the current set point, TVREF EXT (Pin 4) to program over voltage trip, and TIREF EXT (Pin 23) to program over current trip. The power supply has been calibrated to produce full scale output voltage and current with 10.0 V inputs at the external reference input terminals. Furthermore, over voltage and over current trip have been calibrated to trip at 110% full scale output voltage and current with 10.0 V inputs at the external reference input terminals. Most commonly, IREF EXT (Pin 22), TVREF EXT (Pin 4), and TIREF EXT (Pin 23) are all jumpered together and tied to +10V REF (Pin 21).

3.3.2.2. External Current Source Programming

To produce an external analog voltage reference to VREF EXT (Pin 3), a current source is applied to a shunt resistor. Using a 2 mA current source, place a 10.0 K precision metal film resistor between VREF EXT (Pin 3) and REF GND (Pin 1). The input impedance between terminals 1 and 3 is 10.0 K and paralleling the additional resistor produces an equivalent resistance of 5 K. The 2 mA current source will produce 10.0 V at the external voltage reference input which will produce full scale output voltage.

The current set point, over voltage trip, and over current trip can be programmed in the same manner. Referring to the *Section 3.3.1, "External 37-pin I/O Pin Definitions"* for terminal identification, use IREF EXT (Pin 22) to program the current set point, TVREF EXT (Pin 4) to program over voltage trip, and TIREF EXT (Pin 23) to program over current trip. The power supply has been calibrated to produce full scale output voltage and current with 10.0 V inputs at the external reference input terminals. Furthermore, over voltage and over current trip have been calibrated to trip at 110% full scale output voltage and current with 10.0 V inputs at the external reference input terminals. Most commonly, IREF EXT (Pin 22), TVREF EXT (Pin 4), and TIREF EXT (Pin 23) are all jumpered together and tied to +10V REF (Pin 21).

3.3.2.3. External Resistive Source Programming

Resistive programming requires connection of an external potentiometer or resistors between +10V REF (Pin 21), VREF EXT (Pin 3), and REF GND (Pin 1) of the JS1 connector. +10V REF (Pin 21)

is a 10.0V precision reference, REF GND (Pin 1) is the reference ground, and VREF EXT (Pin 3) is the voltage set point input. Like front panel rotary control, the precision reference produces a voltage across the potentiometer or resistors which is then used to produce the voltage set point. Metal film resistors or a wire wound potentiometer will result in the lowest temperature coefficient.

The current set point, over voltage trip, and over current trip can be programmed in the same manner. Referring to the *Section 3.3.1, "External 37-pin I/O Pin Definitions"* for terminal identification, use IREF EXT (Pin 22) to program the current set point, TVREF EXT (Pin 4) to program over voltage trip, and TIREF EXT (Pin 23) to program over current trip. The power supply has been calibrated to produce full scale output voltage and current with 10.0 V inputs at the external reference input terminals. Furthermore, over voltage and over current trip have been calibrated to trip at 110% full scale output voltage and current with 10.0 V inputs at the external reference input terminals. Most commonly, IREF EXT (Pin 22), TVREF EXT (Pin 4), and TIREF EXT (Pin 23) are all jumpered together and tied to +10V REF (Pin 21).

3.3.3. External Analog Monitoring

Two outputs are provided for monitoring output voltage and current and for use in master/slave series and parallel operation. As illustrated in *Figure 3.13, "Monitoring output (a) voltage and (b) current"*, output monitoring voltage, VO2 (Pin 5), can be obtained by monitoring the voltage between terminals VO2 (Pin 5) of JS1 and REF GND (Pin 1, Pin 2, or Pin 20) of JS1. Output monitoring current, IO2 (Pin 24), can be obtained by monitoring the voltage between terminals IO2 (Pin 24) of JS1 and REF GND (Pin 1, Pin 2, or Pin 20) of JS1. Like the programming inputs, full scale output voltage and current will produce 10.0 V. The output impedance of the analog moniotinr terminals is 100 Ω.

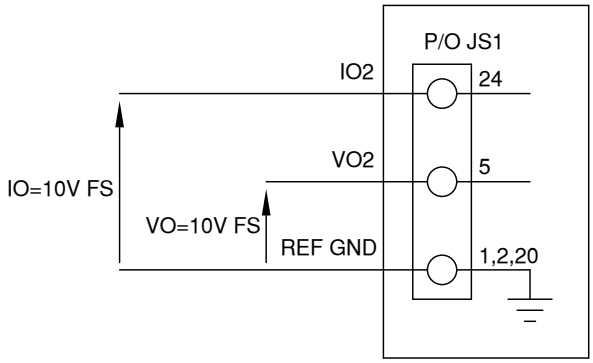

Figure 3.13. Monitoring output (a) voltage and (b) current

3.3.4. Digital Input Lines

All digital input lines are connected to the 37-pin JS1 connector located on the rear panel. As illustrated in *Figure 3.14, "Digital input control lines"*, the digital input lines are START (Pin 17), STOP (Pin 19), CLEAR (Pin 18), and INTERLOCK SET (Pin 37). Functionally, the digital input control lines emulate the functions on the front panel when external control is enabled, indicated by the EXT CTL light on the front panel. Enabling external control is described in *Figure 3.6, "Enable or disable external control mode"*. All digital input lines are triggered by a external momentary (pulsed) 5.0 V signal. If STOP (Pin 19) is left high, it will take presedence over the START (Pin 17) signal.

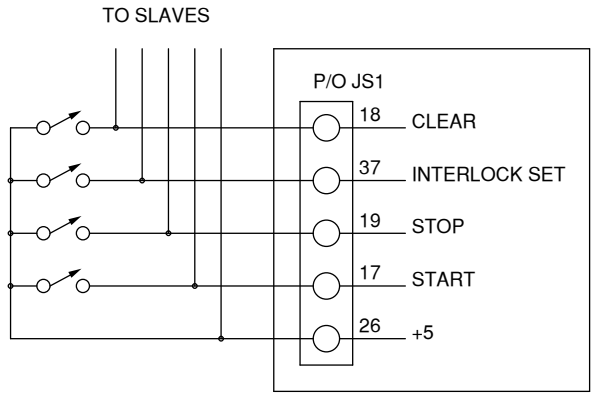

Figure 3.14. Digital input control lines

Interlock set requires a either a physical short between 5.0 V (Pin 26) and INTERLOCK SET (Pin 37) of connector JS1 or application of a 5.0 V source with the positive connection at INTERLOCK SET (Pin 37) of JS1 and the negative connection at GND (Pin 7) of JS1. One of these two connections must be made to enable operation of the power supply. If the interlock connection is broken then the LOC (interlock) fault LED lights, the power supply's internal AC contactor opens, and the unit stops processing power. As illustrated, digital control lines may be paralleled with other supplies to allow simultaneous control.

Note

Before the power supply will accept a reference voltage at INTERLOCK SET (Pin 37), interlock functionality must be enabled either from the front panel or from software. Refer to *Figure 3.10, "Enable or disable external interlock functionality"* for programming from the front panel.

3.3.5. Digital Output Lines

All digital output lines are connected to the 37-pin JS1 connector located on the rear panel. Functionally, the digital output lines provide the means to monitor diagnostic functions as functional status. *Figure 3.15, "Digital output contol lines"* provides terminal identification for the various digital output lines. Each output monitoring line can drive a 5.0 V, 5.0 mA load. An alarm condition will produce a 5.0 V output at the respective terminal.

For a full explanation of all the available digital output lines, refer to *Section 3.3.1, "External 37-pin I/O Pin Definitions"*.

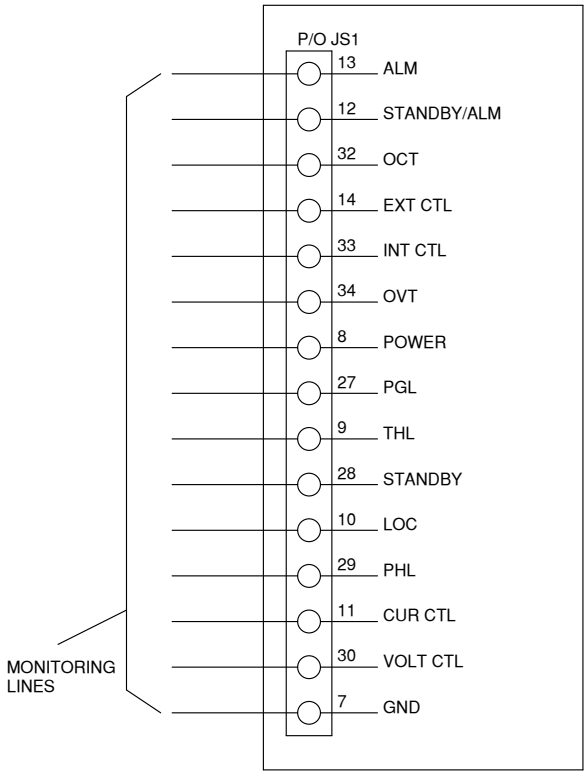

Figure 3.15. Digital output contol lines

Diagnostic functions include thermal overload, interlock, power, standby, phase loss, program line, over voltage, and over current. All diagnostic indicators have memory retention which saves the fault condition until the power supply is reset. To clear a fault condition, the user must press the clear key on the front panel with internal control or by applying 5.0 V to CLEAR (Pin 18) of JS1 with external control enabled. Alternatively, the supply can be cleared by turning the power supply off and on.

Diagnostic functions and control modes are embedded in the product's closed loop control. The power supply will operate using voltage control or current control depending on which setting is lowest. Voltage control and current control also contain a soft start functionality which causes voltage and/or current to ramp to the desired set point after power is initiated. The soft start circuitry is reset upon power-on or operation of any diagnostic function.

3.4. Parallel and Series Operation

3.4.1. Parallel Operation

Two or more XR Series III power supplies can be connected in parallel to obtain a total output current greater than that available from one power supply. The total output current is the sum of the output currents of the individual power supplies. Each power supply can be turned on or off separately.

3.4.1.1. Parallel Operation - Direct

The simplest parallel connection involves attaching the positive terminals of all supplies to be paralleled to the positive point of the load and attaching the negative terminals to the negative point of the load. The output current controls of each power supply can be separately set. The output voltage control of one power supply (master) should be set to the desired output voltage; the other power supply (slave) should be set for a slightly higher output voltage. The master will act as a constant voltage source; the slave will act as a constant current source, dropping its output voltage to equal that of the master.

3.4.1.2. Parallel Operation - Master/Slave

Master/slave parallel operation permits equal current sharing under all load conditions and allows complete control of output current from one master power supply.

Figure 3.16, "Master/Slave parallel connection" illustrates the terminal connection for master/slave parallel operation and salient control circuitry. The control cable can be fabricated by the user or purchased as an option, UID47, from the factory. These connections perform the following functions:

- Jumper connection between ISO (Pin 16) of the slave power supplies and ISI (Pin 35) of the master power supply connects the slave power supplies current monitoring outputs to the master power supply current monitoring input. This connection allows the current of all slave power supplies to be summed along with that of the master power supply.
- Jumper connection between CONTROL (Pin 31) of the master and slave power supplies connects the control lines between the master and slave power supplies. Command of the control line is automatically selected with the jumper connections.
- Jumper connection between REF GND (Pin 2), VREF EXT (Pin 3), IREF EXT (Pin 22) of the slave power supplies to REF GND (Pin 2) of the master power supply enables control of the slave power supplies from the master power supply.
- Jumper connection between POWER (Pin 8) of the master power supply to START (Pin 17) of the slave power supplies connects the power output digital control line of the master power supply to the start digital control line of the slave power supplies. This connection causes slave units to turn on when the master unit is turned on.
- Jumper connection between STANDBY/ALM (Pin 12) of the master power supply and STOP (Pin 19) of the slave power supplies connects the STANDBY/ALM digital control line of the master power supply to the STOP digital control line of the slave power supplies. This connection causes the slaves units to turn off when the master unit is turned off or when a diagnostic condition appears.
- Jumper connections between TVREF EXT (Pin 4), +10V REF (Pin 21), and TIREF EXT (Pin 23) of the slave power supplies sets the slave voltage trip and over current trip set points just beyond full scale values.

The slave power supply must be configured for external program (EXT PGM) input. The master unit can configured for rotary, external program, or remote input. Configuration commands are discussed in *Section 3.2.3, "Configuration Commands"*.

To add a second slave unit, connect the output terminals of the second slave in parallel with the other two power supplies. Furthermore, connect a second control cable between the second slave unit and the master unit.

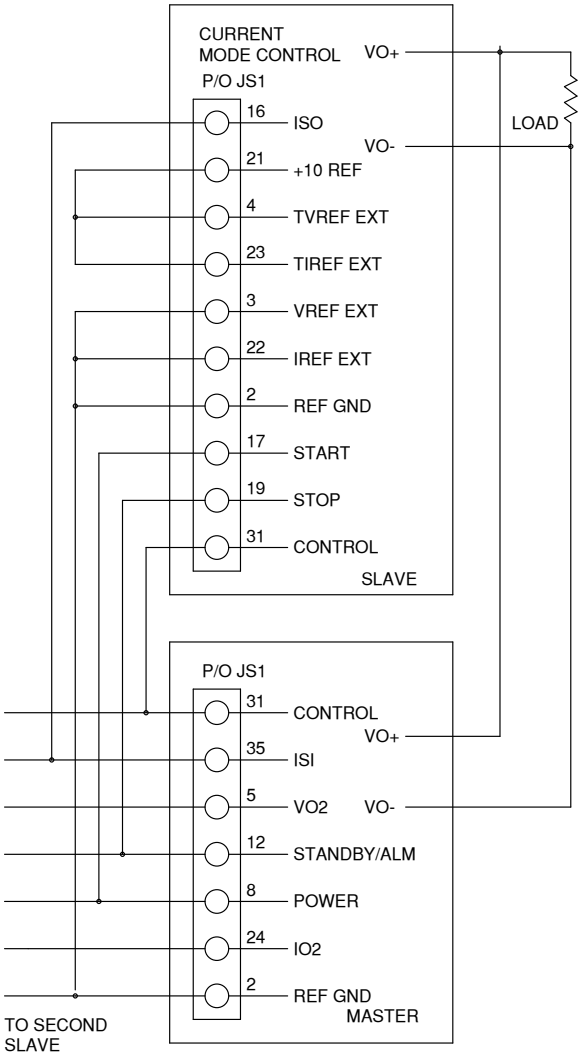

Figure 3.16. Master/Slave parallel connection

3.4.2. Series Operation

Two or more power supplies can be connected in series to obtain a total output voltage greater than that available from one power supply. The total output voltage is the sum of the output voltage of the individual power supplies. Each power supply can be turned on or off separately.

Caution: No plus or minus voltage should exceed ±1000 Vdc. with respect to ground.

3.4.2.1. Series Opeation - Direct

The simplest series connection involves attaching the positive terminal of the first supply to the negative terminal of the second supply. The load is connected between the negative terminal of the first supply and the positive terminal of the second supply. The output current controls of each power supply are operative and the current limit is equal to the lowest control setting. If any one output current control is set too low with respect to the total output current, the series power supplies will automatically crossover to constant current operation and the output voltage will drop.

3.4.2.2. Seies Operation - Master/Slave

Master/slave series operation permits equal voltage sharing under all load conditions and allows complete control of output voltage from one master power supply.

Figure 3.17, "Master/Slave series connection" illustrates the terminal connection for master/slave series operation and salient control circuitry. The control cable can be fabricated by the user or purchased as an option, UID47, from the factory. These connections perform the following functions:

- Jumper connection between VO2 (Pin 5) of the master power supply and VREF EXT (Pin 3) of the slave power supplies connects the voltage monitoring voltage on the master power supply to the external voltage set point input on the slave power supplies. This makes the slave power supplies operate at the same voltage output as the master power supply.
- Jumper connection between POWER (Pin 8) of the master power supply to START (Pin 17) of the slave power supplies connects the power output digital control line of the master power supply to the start digital control line of the slave power supplies. This connection causes slave units to turn on when the master unit is turned on.
- Jumper connection between STANDBY/ALM (Pin 12) of the master power supply and STOP (Pin 19) of the slave power supplies connects the STANDBY/ALM digital control line of the master power supply to the STOP digital control line of the slave power supplies. This connection causes the slaves units to turn off when the master unit is turned off or when a diagnostic condition appears.
- Jumper connections between TVREF EXT (Pin 4), +10V REF (Pin 21), IREF EXT (Pin 22), and TIREF EXT (Pin 23) of the slave power supplies sets the slave current control to maximum and sets the voltage trip and over current trip set points just beyond full scale values.

The slave power supply must be configured for external program input. The master unit can configured for rotary, external program, or remote input. Configuration commands are discussed in *Section 3.2.3, "Configuration Commands"*.

To add a second slave unit, connect the output terminals of the second slave in series with the other two power supplies. Furthermore, connect a second control cable between the second slave unit and the master unit.

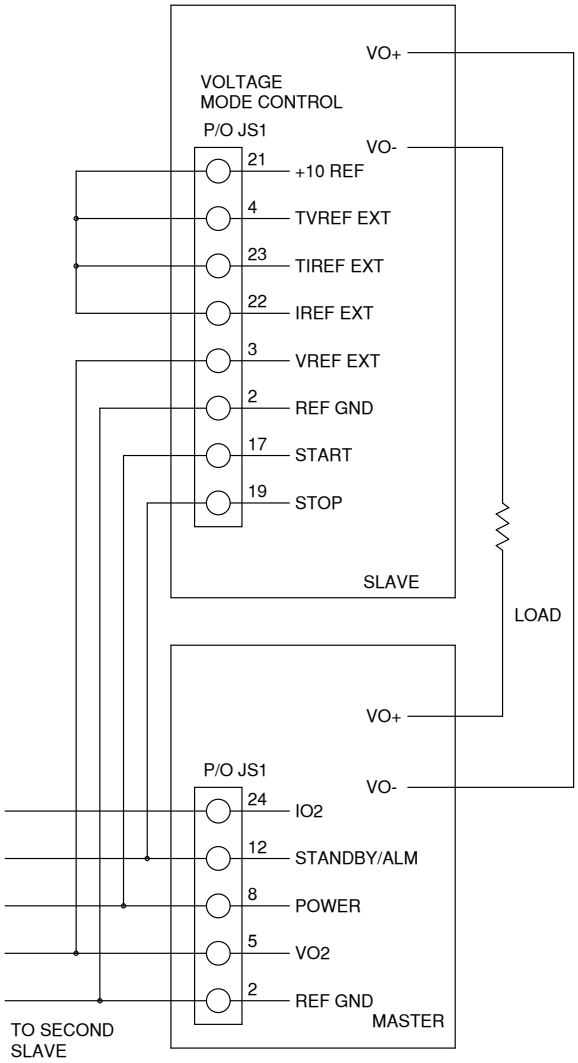

Figure 3.17. Master/Slave series connection

3.5. Troubleshooting Guide

The XR Series III power supplies consist of a multistage power processing system. Because of its complexity, it is highly recommended that all repairs be performed by the factory or a qualified power supply technician. Before attempting maintenance or repair, the technician should be familiar with the components of the systems and the theory of operation. Some basic test equipment is also necessary: source of AC power, means of loading the power supply, DC voltmeter with accuracy and resolution better than the programmable DC power supply specifications, and an oscilloscope.

Caution: When servicing the power supply, dangerous voltage levels exist. All AC and DC capacitors should be discharged. Be especially careful of person and equipment when measuring primary circuitry since this is at line potential.

1. Fuse F1, F2, or F3 blows when the power supply is turned on. Power supply has a short on the primary side.
   - Check diode bridge DB1.
   - Check for failed power semiconductor on the Chopper Module.
   - Check for isolation to ground on the input side of the power supply.

2. Over current trips and power supply cannot be reset. An auxiliary over current detector limits input DC link current. Exceeding safe levels will cause an over current diagnostic condition that cannot be reset.
   - Restart the supply. Transient voltages on the input voltage could have caused the problem.
   - Check diodes D1 through D4 on the secondary side of transformer T1.
   - Check for a shorted winding on transformer T1.
   - Check for failed IGBT's in the chopper and current fed inverter circuitry.
3. Unit goes to high output immediately after starting.
   - Check for loose connectors internal to the power supply.
4. High ripple voltage.
   - Check the mains voltage for balance and magnitude.

3.6. Calibration

3.6.1. Contol Board

The control board contains digital potentiometers for fine adjustments of the reference and feedback amplifiers. These potentiometers may be adjusted by using the front panel controls described in *Section 3.2.4, "Calibration Commands"*. These potentiometers can also be adjusted by using the Calibration Panel of the Remote Interface Software described in *Section 4.5, "Calibration Panel"*.

3.6.1.1. Reference Amplifier Calibration

Connect a voltmeter between terminal 6 of JS1 (positive) and terminal 1 of JS1 (negative). With only the control power applied, adjust potentiometer P5 for a 2.5006 V.

3.6.1.2. Voltage Feedback Amplifier Calibration

Place a DC voltmeter across the output terminals of the power supply and place a second DC voltmeter to monitor VO2, the voltage between terminal 5 of JS1 (positive) and terminal 1 of JS1 (negative). Set the load to 50% rated output current at full scale voltage.

With only the control power applied, adjust potentiometer P2 for 0.000 V at VO2. Using the up/down (V/I DIS or TRIP DIS) keys or RS232 remote interface, set the output voltage to 50% full scale output. Turn on the power supply and adjust potentiometer P1 until the output voltage matches the set point voltage. Now set the output voltage to its full scale rating and measure the output voltage. Adjust potentiometer P1 to equally divide the error between the half scale set point and the full scale point.

3.6.1.3. Current Feedback Amplifier calibration

Place a DC ammeter in series with the load of the power supply and place a DC voltmeter to monitor IO2, the voltage between terminal 24 of JS1 (positive) and terminal 1 of JS1 (negative). Set the load to 100% rated output current at 90% full scale voltage.

With only the control power applied, adjust potentiometer P4 for 0.000 V at IO2. Using the up/down (V/I DIS or TRIP DIS) keys or RS232 remote interface, set the output current to 50% full scale output. Turn on the power supply and adjust potentiometer P3 until the output current matches the set point

current. Now set the output current to its full scale rating and measure the output current. Adjust potentiometer P3 to equally divide the error between the half scale set point and the full scale point.

3.6.2. Driver Board

The driver board contains two potentiometers which are used to set under voltage and over current protection in the polyphase chopper circuitry. These potentiometer do not normally need adjustment in the field.

3.6.2.1. Over Curent Protection

Over current protection should only be calibrated after consultation with the factory.

Caution: Gross misadjustment can cause chopper and inverter failure.

Place a DC voltmeter between test point TP6 (positive) and test point TP7 (negative). With only the control power applied, adjust potentiometer P1 to 6.00 V.

3.6.2.2. Under Voltage Protection

Under voltage protection should only be calibrated after consultation with the factory.

Caution: Gross misadjustment can cause chopper and inverter failure.

Connect the power supply to an adjustable AC source and connect an ac voltmeter to monitor the voltage applied to the input terminals. Tests can be performed under no load conditions. Set the ac source to rated voltage. Turn the control power, press the start switch, and a adust the output voltage to 10% full scale output. Decrease the ac source to a value between 75% to 82% of rated voltage. Adjust potentiometer P2 until the output drops to zero; the transition will be abrupt.

Decrease the ac source to a value between 72% to 79% of rated voltage. The main contactor should turn off.

Remote Interface Software

The Remote Interface Software is shipped with XR Series III programmable DC power supplies. The software provides the user with a quick method to operate a Magna-Power Electronics power supply under computer control. The Remote Interface Software has six windows: the Virtual Control Panel, Command Panel, Register Panel, Calibration Panel, Firmware Panel, and Modulation Panel. The Virtual Control Panel emulates the front panel of the XR Series power supply, the Command panel programs and reads SCPI commands with user friendly buttons, the Register Panel programs and reads registers, the Calibration Panel enables calibration of the digital potentiometers, the Firmware Panel enables the program stored internal to the power supply to be upgraded, and the Modulation Panel eases programming of modulation parameters.

4.1. Application Setup

To communicate with the power supply, the front panel version, type of communication, address and/or port need to be specified. The options are:

1. Power supply series: Select the appropriate version corresponding to the power supply front panel type.
2. Communications interface: RS232, RS485, IEEE-488 GPIB, LXI TCP/IP Ethernet, simulated, or others depending on future developments. *Figure 4.1, “RIS Panel Configuration Setup”* displays the Applications Setup Window. Address requirements are:
    - RS232: Port
    - RS485: Address and port, 1-30
    - IEEE-488: Address, 1-30
    - Ethernet: Address and port

Figure 4.2, “LXI Communications Setup” illustrates the communications setup for LXI TCP/IP Ethernet communications. The address specifies the desired device on the network to establish communications. To locate a particular device or to set a new address, press Find Device or Change Device's setting, respectively. The Find Devices panel displays all devices on the bus that are available for communications, as shown in *Figure 4.3, “Find LXI TCP/IP Ethernet device”*. The Change Device's Setting allows the address of the particular device to be changed. When changing a device's address, the address in the Communication Setup will also change allowing continued communications. Similar panels are displayed for IEEE 488 GPIB, RS232, and RS485 communications.

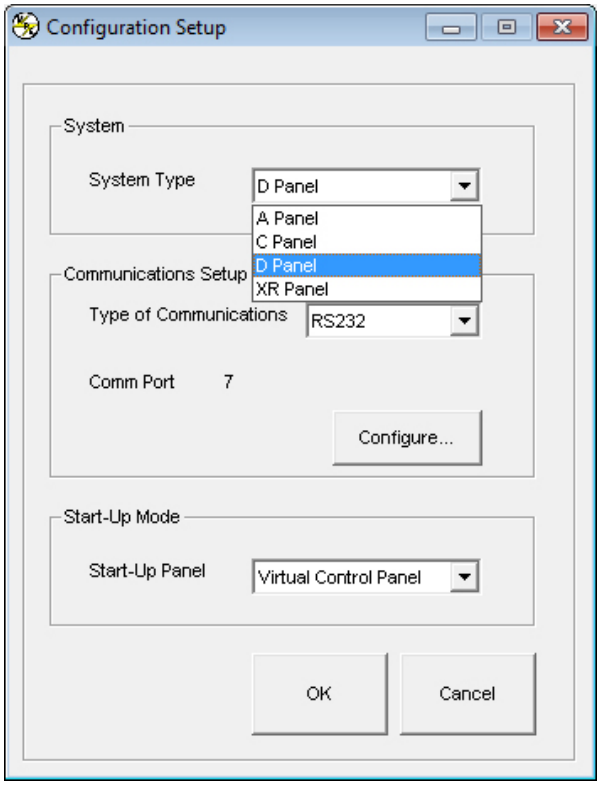

Figure 4.1. RIS Panel Configuration Setup

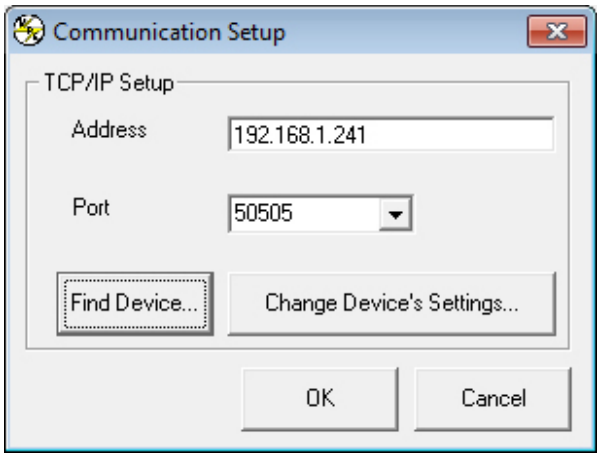

Figure 4.2. LXI Communications Setup

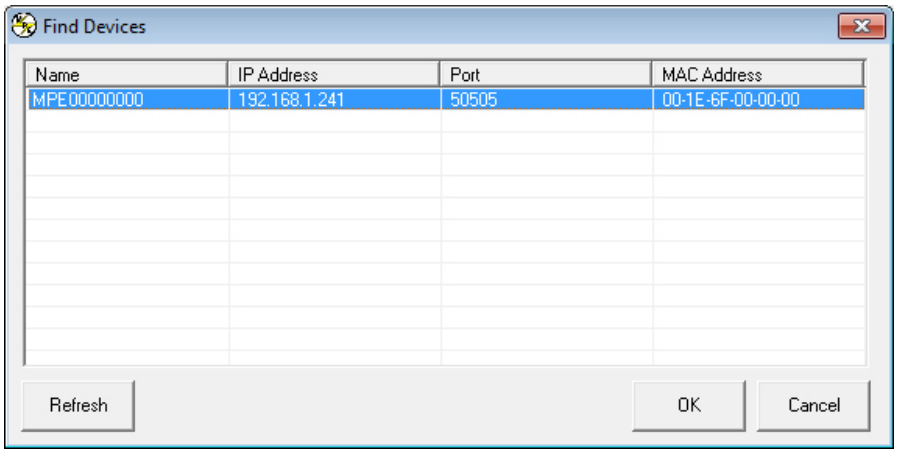

Figure 4.3. Find LXI TCP/IP Ethernet device

4.2. Virtual Control Panel

Figure 4.4, "Virtual Control Panel" illustrates the Virtual Control Panel for the D Version front panel models. Other displays are available for the XR front panel and the A Version front panel. The Virtual Control Panel emulates front panel commands and provides the means to control the C Version front panel models.

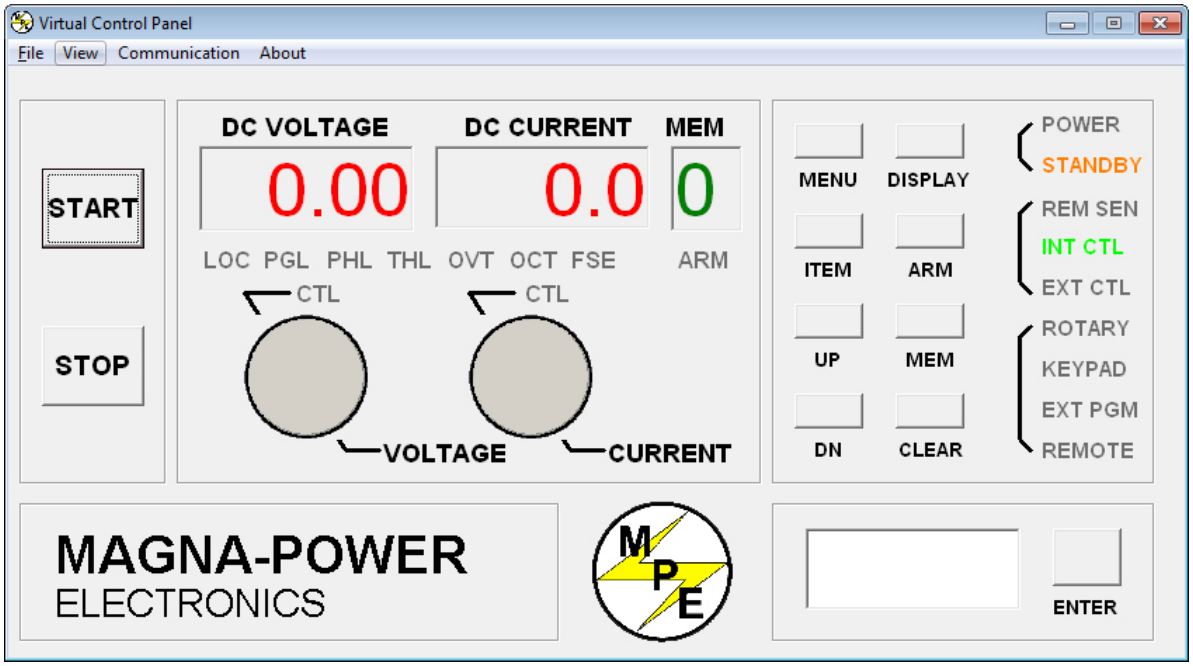

Figure 4.4. Virtual Control Panel

4.3. Command Panel

The Command Panel is illustrated in *Figure 4.5, "Command Panel"*. The Command Panel is organized into three groups: commands and queries requiring data input, commands with only command syntax, and commands with only query syntax. The Output frame on the right of the window echoes the SCPI command used to communicate with the power supply. This feature provides the user with the proper syntax for each command. The Output frame can be cleared or saved to a file by pressing the clear button or the save to file button. Commands in gray are not accessible with the particular configuration.

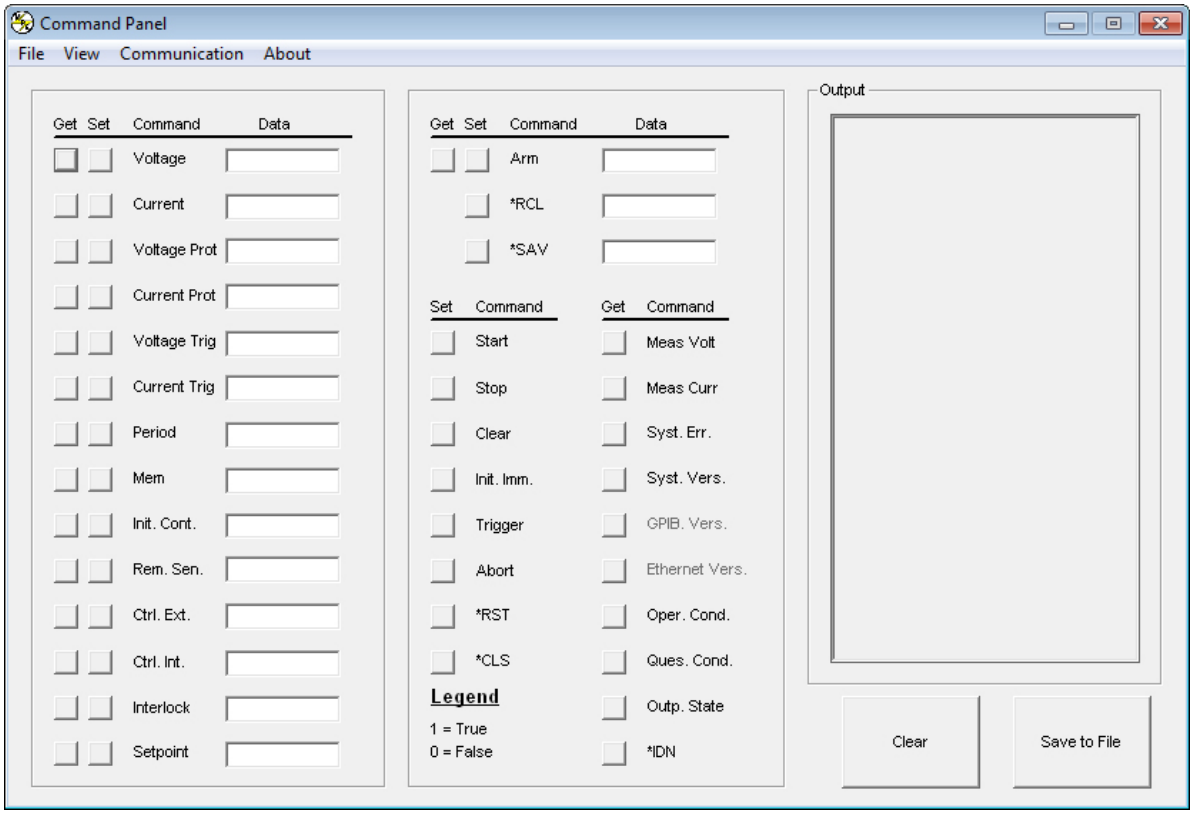

Figure 4.5. Command Panel

4.4. Register Panel

The Register Panel is illustrated in *Figure 4.6, "Register Panel"*. The Register Panel graphically represents the six internal registers of the power supply. Register functions, covered in the next Chapter, are briefly summarized below:

- Operation Register (oper): indicates the power supply's current operational state. The register is unlatched and is described in *Section 5.1.9.1, "STAT:OPER:COND?"*.
- Questionable Register (ques): indicates the current state of power supply alarms. The register is unlatched and is described in *Section 5.1.9.2, "STAT:QUES:COND?"*.
- Status Byte Register (STB): indicates communications error messages. The register is latched and is described in *Section 5.3.3.6, "Read Status Byte Register"*.
- Service Request Enable Register (SRE): a mask register for the STB. The register is described in *Section 5.3.3.7, "Read and Set Service Request Enable Register"*.
- Standard Event Status Register (ESR): a latched register which is similar to STB except it provides more details. The register is described in *Section 5.3.3.4, "Read Event Status Register"*.
- Event Status Enable Register (ESE): mask register for the ESR. The register is described in *Section 5.3.3.5, "Read and Set Event Status Enable Register"*

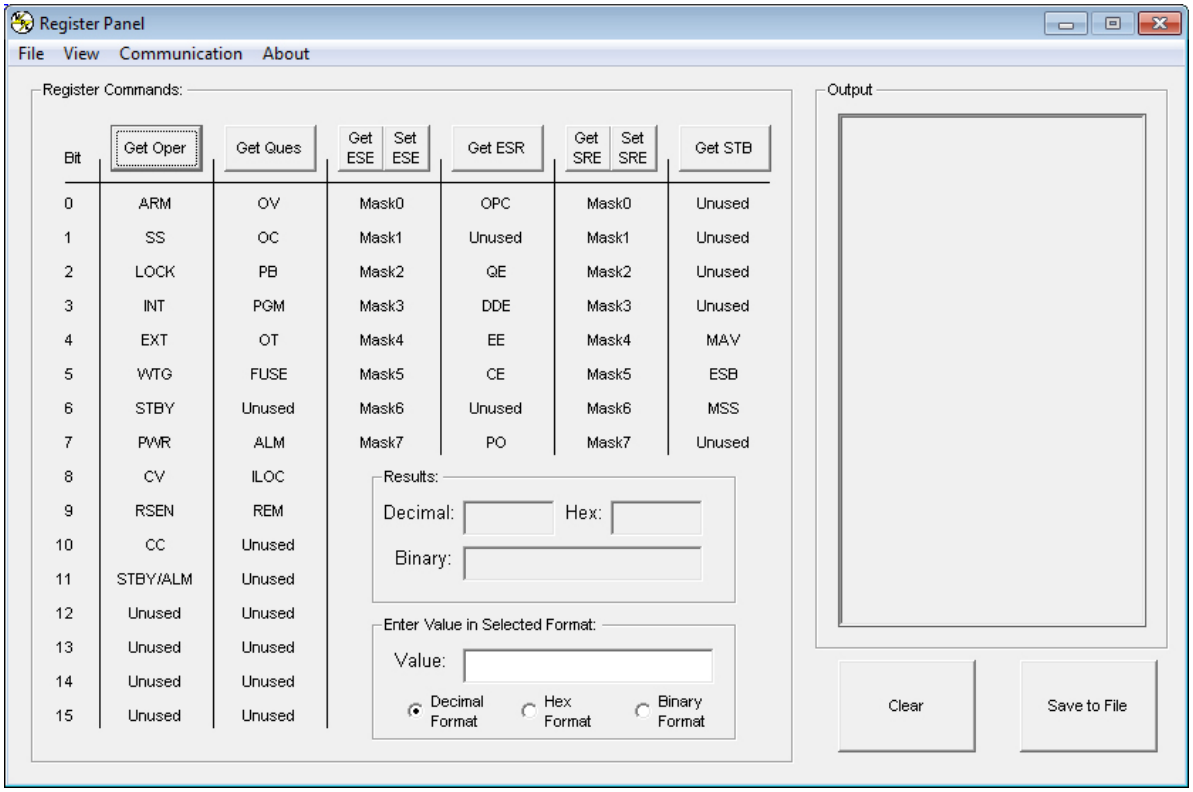

Figure 4.6. Register Panel

As illustrated in the Register panel, each column denotes a register value, and the rows, marked by the leftmost column, are the bit positions. The get button at the column heading will acquire the respective register value for the power supply. The labels in each column indicate the meaning of each bit. For example, bit 5 in the Ques column will light if fuse alarm is activated. The mask registers, SRE and ESE, can be modified via the set button in their column heading. Enter the value in the "Enter Value in Selected Format" frame, and then press the set button. If no errors occur, then the new value will appear after the get button is pressed. The Results frame displays the returned register value in decimal, hex and binary formats. The "Enter Value in Selected Format" frame allows the user to specify the format for data entry.

The Output frame shows all communications with the power supply. The Output frame can be cleared or saved to a file by pressing the clear button or the save to file button.

4.5. Calibration Panel

The Calibration Panel, illustrated in *Figure 4.7, "Calibration Panel"*, provides easy access and programmability for the digital potentiometers. The Calibration Panel is password protected. To enable changes, enter 1234 for the password and then press the adjacent set button. The five digital potentiometers can accept numbers from 0 to 255. Further commands include setting the potentiometer to the factory default setting and end calibration procedure. The Output frame shows all communications with the power supply. The Output frame can be cleared or saved to a file by pressing the clear button or the save to file button.

Voltage Scale and Current Scale are not available to the user. These are factory specific commands that require an alternate password to access.

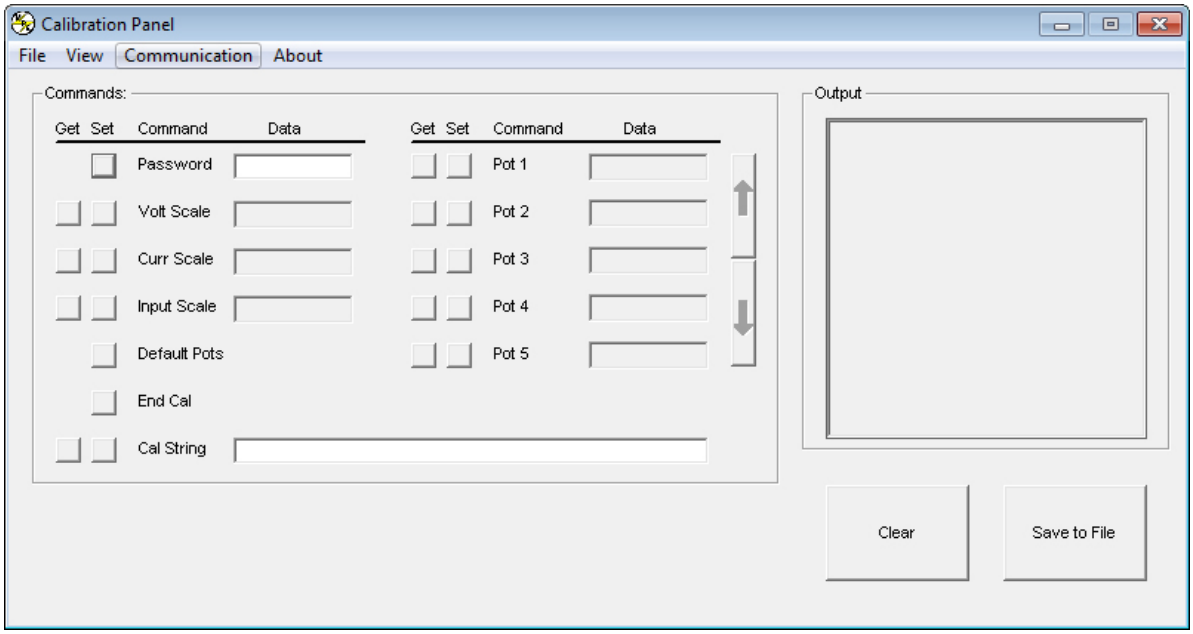

Figure 4.7. Calibration Panel

4.6. Firmware Panel

The Firmware Panel is illustrated in *Figure 4.8, "Firmware Panel"*. The Firmware Panel enables the program stored internal to the power supply to be upgraded. The factory recommends that firmware upgrades be performed only if there is an operational problem with the power supply.

The following steps list the procedure for upgrading the firmware:

- Turn the power supply off.
- Connect a RS232 cable between a serial port on a computer and connector JS3 on the power supply.
- Press the select button and choose the file to be loaded.
- Press the start button. The Status frame will display "Initiating."
- Turn on the power supply. If the supply is not turned on within 10 seconds, "Time Out" will be displayed in the Status frame indicating communications is lost.

During the process of upgrading the firmware, the front panel of the power supply will remain blank. After communications is established, the Status frame will initially display "Erasing" and the Current Address frame will display the address in memory being erased. After the entire memory is erased, the Status frame will display "Loading " and the Current Address frame will display the address in memory being loaded. The Status frame will display "Finished" and the front panel display will return to normal after the memory is reprogrammed.

Pressing the stop button will terminate execution at any time.

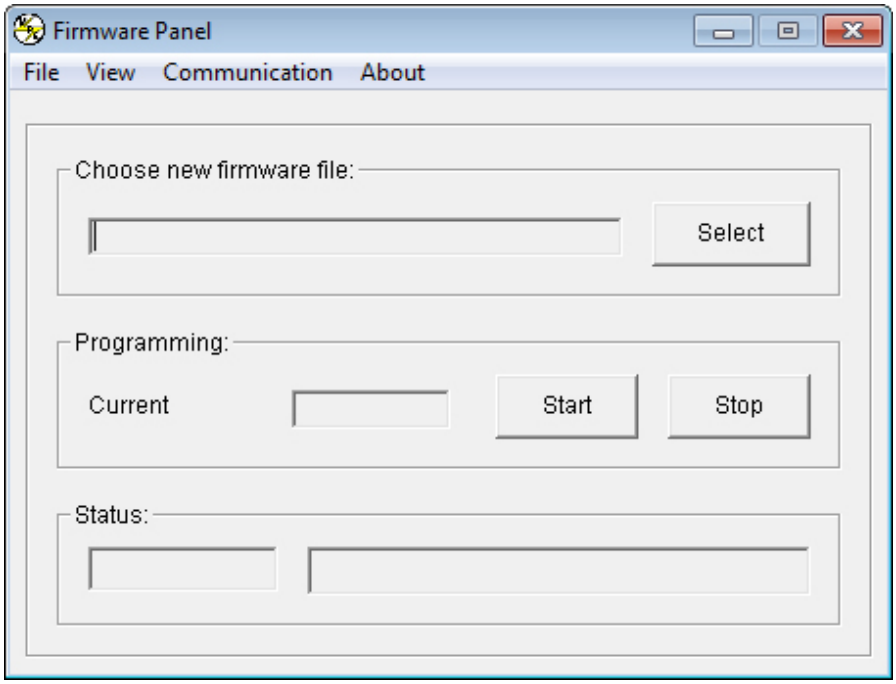

Figure 4.8. Firmware Panel

4.7. Modulation Panel

The Modulation Panel is illustrated in *Figure 4.9, "Modulation Panel"*. The Modulation Panel enables a user to set and view the modulation settings as described in *Section 5.1.6, "Modulation Commands"*. The modulation settings consist of control input, modulation type (multiplication or addition), table row, modulation voltage input, and modulation factor. The Modulation Panel provides the form to program a linear or piece-wise linear lookup table for the selected modulation type. The lookup table can have a maximum of 50 data points. The modulation voltage input, VMOD, must be entered in ascending order. For lookup tables with less than 50 data points, VMOD must be terminated with a Mod value of 9999. Any data entered for modulation factor on the terminating row is ignored. The Output frame on the right of the window displays all of the communications with the power supply. The Output frame can be cleared or saved to a file by pressing the clear button or the save to file button. More details about the modulation functionality's principle of operation are available in *Section 5.1.6, "Modulation Commands"*

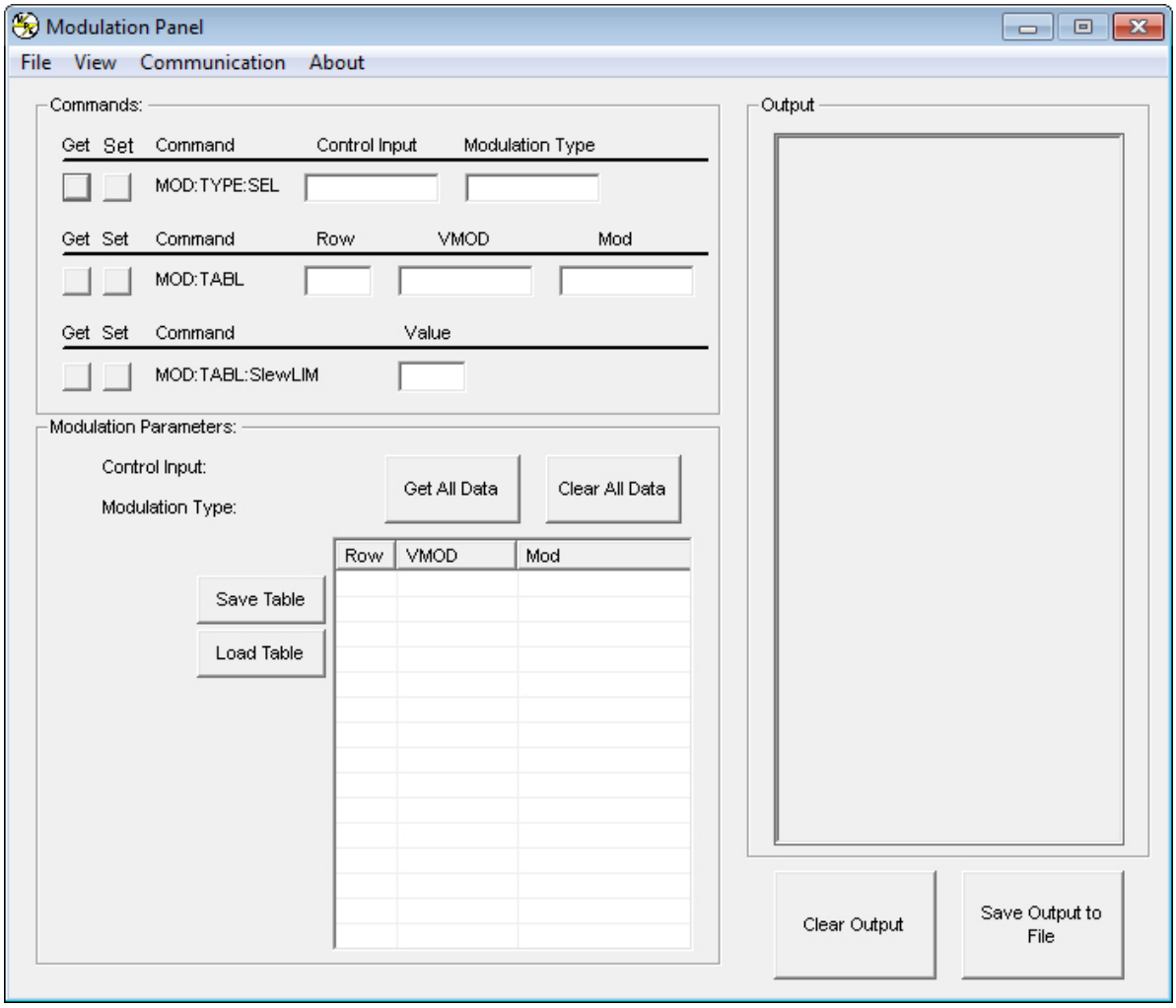

Figure 4.9. Modulation Panel

Computer Programming

There is a versatile range of methods and interfaces that can be used to program the XR Series III programmable DC power supply from a computer or programmable logic controller. Standard Commands for Programmable Instrumentation (SCPI) are provided for basic ASCII interfacing without any necessary drivers; these commands are documented in *Section 5.1, "SCPI Commands"*. In addition, an IVI-COM Driver is included with the installation CD and is available for download from the Magna-Power Electronics web page for more advanced programming requirements. The driver allows the power supply to communicate through many different programming languages and software environments, namely: Visual C++, Visual C#, Visual Basic .NET, Visual Basic 6.0, LabVIEW, LabWindows/CVI, MATLAB, Measure Foundry, and Agilent VEE Pro. Refer to *Section 5.7, "IVI-COM Driver"* for further details.

XR Series III products purchased with optional LXI TCP/IP Ethernet (+LXI) or IEEE-488 GPIB (+GPIB) interfaces have additional commands and programming instructions, detailed in *Section 5.4, "LXI TCP/IP Ethernet Communications"* and *Section 5.3, "IEEE-488 GPIB Communications"*, respectively.

5.1. SCPI Commands

Standard Commands for Programmable Instrumentation (SCPI) are provided for Magna-Power Electronics products. These commands provide programming compatability with other instruments. SCPI commands are ASCII textual strings, which are sent to the instrument over the physical layer. Commands are a series of one or more keywords—many of which take parameters. The subsections provide more details on all the supported commands. For commands related to optional IEEE-488 GPIB interface and LXI TCP/IP Ethernet interface refer to *Section 5.3.3, "IEEE-488 GPIB SCPI Commands and Registers"* and *Section 5.4.3, "LXI TCP/IP Ethernet SCPI Commands"*, respectively.

The following syntax is used in this manual.

SCPI Syntax

Square Brackets [ ]

Items within the square brackets are optional. Brackets plus their contents can be omitted when the command is issued.

Angle Brackets < >

Items within the angle brackets, indicating a specific data type, provide parameter descriptions. See *Section 5.1.1, "Parameter Data Types"* for more information.

5.1.1. Parameter Data Types

Table 5.1. SCPI Parameter Data Types

Symbol	Data Type	Example(s)
<>	Null, no data.	
<NR1>	Digits with an implied decimal point assumed at the right of the least-significant digit.	-326 326
<NR2>	Digits with an explicit decimal point.	-32.6 3.26
<NR3>	Digits with an explicit decimal point and an exponent.	3.26E+2 326.0E-2
<NRf>	Extended format that includes <NR1>, <NR2> and <NR3>.	326 -326.0 3.26E2

Symbol	Data Type	Example(s)
<NRf+>	Expanded decimal format that includes <NRf>, MIN, and MAX, where MIN and MAX are the minimim and maximum limit values in the range specification for the parameter.	326 -326.0 3.26E2 MAX
<bool>	Boolean data, can be numeric (0, 1) or name (OFF, ON).	1 ON
<string>	String program data, enclosed in either single or double quotes.	Magna-Power Electronics

5.1.2. Restricted SCPI Command Set

Commands and queries described in *Section 5.1, "SCPI Commands"* require the power supply to be configured for REMOTE operation. There are instances, however, when the power supply may be configured for ROTARY or EXT PGM and use of certain SCPI command from a computer interface features may be desirable. As defined in *Table 5.2, "Restricted SCPI command set available while in ROTARY or EXT PGM configuration"*, a reduced set of commands and queries are available during these modes of operation, enabling allowing for computer communications at all times.

Table 5.2. Restricted SCPI command set available while in ROTARY or EXT PGM configuration

		XR Panel		XRC Panel	
Command Type	Command/Query Example	Command	Query	Command	Query
Calibration	CAL:IDN		•		•
	CAL:PASS				
	CAL:POT		•		•
	CAL:SCAL:VOLT		•		•
	CAL:SCAL:CURR		•		•
	CAL:SCAL:INP		•		•
	CAL:DEF				
	CAL:STOP				
Configuration	CONT:INT	•	•	•	•
	CONT:EXT	•	•	•	•
	REM:SENS	•	•	•	•
	INTE	•	•	•	•
	CONF:SETPT	•	•	•	•
Measure	MEAS:VOLT?		•		•
	MEAS:CURR?		•		•
Modulation	MOD:TYPE:SEL	•	•	•	•
	MOD:TABL	•	•	•	•
	MOD:SAVE		•		•
	MOD:TABL:LOAD	•		•	
Output	OUTP?		•		•
	OUTP:ARM				
	OUTP:START	•		•	

Command Type	Command/Query Example	XR Panel		XRC Panel	
		Command	Query	Command	Query
	OUTP:STOP	•		•	
	OUTP:PROT:CLE	•		•	
Source	VOLT AND VOLT:TRIG		•		•
	VOLT:PROT	•	•	•	•
	CURR AND CURR:TRIG		•		•
	CURR:PROT	•	•	•	•
Status	STAT:OPER:COND?		•		•
	STAT:QUES:COND?		•		•
System	SYST:VERS?		•		•
	SYST:ERR?		•		•
Trigger	TRIG				
	INIT		•		•
	ABORt				
LXI Ethernet TCP/IP Communications	NET:VERS?		•		•
	NET:MAC?		•		•
	NET:SER?		•		•
	NET:ADDR	•	•	•	•
	NET:GATE	•	•	•	•
	NET:SUBN	•	•	•	•
	NET:PORT	•	•	•	•
	NET:HOST	•	•	•	•
	NET:DHCP	•	•	•	•
IEEE-488 GPIB Communications	GPIB:VERS?		•		•
	GPIB:ADDR	•	•	•	•
	*CLS	•		•	
	*ESR?		•		•
	*ESE	•	•	•	•
	*STB?		•		•
	*SRE?	•	•	•	•
	*IDN?		•		•
	*SAV				
	*RCL				
	*RST				

5.1.3. Calibration Commands

5.1.3.1. CAL:IDN

Description

This command updates the power supply's identification string for the power supply model. The **CAL:IDN** string can have up to 100 characters. Before this command can be used, a password must be validated by CAL:PASS. Typically, this command is for Magna-Power Electronics use only.

Command Syntax

CALibrate:IDN <string>

Parameters

Company Name, Power Supply Model, Serial Number

Examples

CAL:IDN Magna-Power Electronics Inc., TSD16-900, S/N: 1161-5225

Query Syntax

CAL:IDN?

Returned Parameter

<string>

Related Commands

***IDN**

5.1.3.2. CAL:PASS

Description

This command protects against system calibration corruption and initiates the calibration sequence.

Command Syntax

CAL:PASS <NR1>

Examples

CALIBRATE:PASSWORD 1234
CAL:PASS 1234

5.1.3.3. CAL:POT

Description

This command sets the value for the specified potentiometer. The variable specifies the potentiometer to be adjusted, 1 thru 5, and the second variable specifies the potentiometer setting, 0 through 255.

Command Syntax

CALibrate:POT <NR1>,<NR2>

Examples

CALIBRATE:POT 1,123
CAL:POT 5,11

Query Syntax

CALibrate:POT?

Returned Parameter

<NR1>

5.1.3.4. CAL:SCAL:VOLT

Description

This command sets the voltage scale factor for the power supply.

Command Syntax

CALibrate:SCALe:VOLTage <NRf>

Examples

CALIBRATE:SCALE:VOLTAGE 16.0
CAL:SCAL:VOLT 16.0

Query Syntax

CALibrate:SCALe:VOLTage?

Returned Parameter

<NR3>

5.1.3.5. CAL:SCAL:CURR

Description

This command sets the current scale factor for the power supply.

Command Syntax

CALibrate:SCALe:CURRent<NRf>

Examples

CALIBRATE:SCALE:CURRENT 900.0
CAL:SCAL:CURR 900.0

Query Syntax

CALibrate:SCALe:CURRent?

Returned Parameter

<NR3>

5.1.3.6. CAL:SCAL:INP

Description

This command sets the full scale external programming inputs for voltage, current, over voltage trip, and over current trip. The scaling factor for the programming inputs must match the scaling factor set with hardware on the control board.

Command Syntax

CALibrate:SCALe:INPut<NRf>

Examples

CALIBRATE:SCALE:INPUT 10.0
CAL:SCAL:INP 10.0

Query Syntax

`CALibrate:SCALe:INPut?`

Returned Parameter

`<NR3>`

5.1.3.7. CAL:DEF

Description

This command sets the Calibration potentiometers to the factory defaults.

Command Syntax

`CALibrate:DEFaults`

Examples

`CALibrate:DEFaults`
`CAL:DEF`

5.1.3.8. CAL:STOP

Description

This command terminates the calibration subsystem.

Command Syntax

`CALibrate:STOP`

Examples

`CALibrate:STOP`
`CAL:STOP`

5.1.4. Configuration Commands

5.1.4.1. CONT:INT

Description

This command enables or disables the front panel switches and keys for start, stop, arm, and clear.

The query command, **`CONT:INT?`**, returns the status of internal control.

Command Syntax

`[CONFigure]:CONTrol:INTernal <bool>`

Parameters

0 | OFF
1 | ON

Examples

`CONF:CONT:INT ON`
`CONT:INT 0`

Query Syntax

`[CONFigure]:CONTrol:INTernal?`

Returned Parameter

0 | 1

5.1.4.2. CONT:EXT

Description

This command enables or disables the external inputs for start, stop, arm, and clear.

The query command, **CONT:EXT?**, returns the status of external control.

Command Syntax

[CONFigure]:CONTrol:EXTernal <bool>

Parameters

0 | OFF
1 | ON

Examples

CONF:CONT:EXT ON
CONT:EXT 0

Query Syntax

[CONFigure]:CONTrol:EXTernal?

Returned Parameter

0 | 1

5.1.4.3. REM:SENS

Description

This command sets voltage sensing to remote or local mode. Remote sensing, as described in *Section 2.4.1, "Remote Voltage Sensing"*, improves the degradation of regulation which will occur at the load when the voltage drop in the connecting wires is appreciable. The local sense mode monitors the voltage at the output terminals of the power supply.

The query command, **REM:SENS?**, returns the state of the sense lines.

Command Syntax

[CONFigure]:REMote:SENSe <bool>

Parameters

0 | OFF
1 | ON

Examples

CONF:REM:SENS ON
REMOTE:SENSE 0

Query Syntax

[CONFigure]:REMote:SENSe?

Returned Parameter

0 | 1

5.1.4.4. INTE

Description

This command enables or disables the external interlock feature. Interlock, described in *Section 3.3.4, "Digital Input Lines"*, is used for applications where the power supply needs to be disabled under external conditions.

The query command, **INTE?**, returns the status of external interlock.

Command Syntax

[CONFigure]:INTErlock

Parameters

0 | OFF
1 | ON

Examples

CONF:INTE ON
INTE 0

Query Syntax

[CONFigure]:INTErlock?

Returned Parameter

0 | 1

5.1.4.5. CONF:SETPT

Description

This command sets the operational mode of the power supply: ROTARY, KEYPAD, EXT PGM, or REMOTE. Keypad configuration is available for TS Series, MS Series, and MT Series supplies with the D-Version front panel.

The query command, **CONF:SETPT?**, returns the operation mode of the power supply.

Command Syntax

[CONFigure]:SETPT <NR1>

Parameters

0 | ROTARY
1 | KEYPAD
2 | EXT PGM
3 | REMOTE

Examples

CONF:SETPT 0
SETPT 0

Query Syntax

[CONFigure]:SETPT?

Returned Parameter

<NR1>

5.1.5. Measure Commands

5.1.5.1. MEAS:VOLT?

Query Syntax

MEASure:VOLTage[:DC]?

Examples

MEAS:VOLT?
MEASURE:VOLTAGE:DC?

Returned Parameter

<NR2>

5.1.5.2. MEAS:CURR?

Query Syntax

MEASure:CURRent[:DC]?

Examples

MEAS:CURR?
MEASURE:CURRENT:DC?

Returned Parameter

<NR2>

5.1.6. Modulation Commands

The Modulation Subsystem, available on XR Series models or models with the D-Version front panel, adjusts the output voltage or current according to the voltage measured on the external analog input, pin 25 of JS1, named VMOD. This signal has an allowed input range 0-10 V. Modulation requires the power supply to be configured for remote mode. Rotary control mode or external program control mode cannot be used with these commands.

Modulation allows a set point adjustment of voltage or current by another input. The modulation signals can be derived from an external device, such as a thermistor, or from the sampling of the output current or voltage. When used with software containing advanced numerical methods, feeding the output voltage or current to adjust the set point current or voltage allows user defined output profiles. The system, incorporating this feature, introduces another negative feedback path with gain controlled by a user programmed attenuator.

Modulation can be introduced into the control loop either adding a variable to the set point or by multiplying a variable with the set point. Additive functions are useful for introducing series and parallel impedances and multiplier functions are useful for adjusting voltages or currents sources. *Table 5.3, "Modulation Function Subsystem Parameters"* describes the four options: control input 1 and 2 for voltage and current control and control type 0 and 1 for multiplier and additive functions.

5.1.6.1. MOD:TYPE:SEL

This command is composed of two comma separated, modulation parameters. The first parameter, control input, defines whether the modulation table adjusts output voltage or output current. When the control input is set to 1, VMOD selects the modulation table to adjust output voltage. When control input is set to 2, VMOD selects the modulation table to adjust output current. Setting the control input to the default value of 0, disables the modulation function. Information on programming the lookup table is provided in *Table 5.4, "Modulation Table Parameters"*.

The second command parameter, control type, defines the expression for modulating output voltage or current. With type set to 0, table data points are used in a multiplying expression. With type set to 1, table data points are used in an addition expression.

The choice of using type 0 or type 1 modulation depends on the application. Only one set point can be modulated at any given time. The query command returns two comma separated parameters, the control input followed by the control type.

Table 5.3. Modulation Function Subsystem Parameters

Control Input	Control Type	
	0	1
(Default) 0	Disabled	Disabled
1	$V_o=G_v[V_{ref}\times Mod(VMOD)]$	$V_o=G_v[V_{ref}+Mod(VMOD)]$
2	$I_o=G_i[I_{ref}\times Mod(VMOD)]$	$I_o=G_i[I_{ref}+Mod(VMOD)]$

Notes:

1. V_o is the adjusted output voltage as a function of the modulation operator
2. I_o is the adjusted output current as a function of the modulation operator
3. V_{ref} is input voltage set point reference
4. I_{ref} is input current set point reference
5. VMOD is the input modulation set point reference
6. G_v is the system gain as define by the full scale output voltage, V_{fs}, divided by the maximum input voltage set point reference, $V_{ref,max}$
7. G_i is the system gain as define by the full scale output current, I_{fs}, divided by the maximum input current set point reference, $I_{ref,max}$

Mod(VMOD), modulation, can be an expression, constant, or other numerical operator. A user friendly method chosen by Magna-Power Electronics is a table based algorithm using piecewise linear approximation. This numerical method allows linear or non-linear modulation to be introduced simply be defining the constants in a table.

Command Syntax

```
MODulation:TYPE:SELect <NR1>[,<NR1>]
```

Examples

```
MOD:TYPE:SEL 1,0
MOD:TYPE:SEL 2,1
MODulation:TYPE:SELect 0
```

Query Syntax

```
MODulation:TYPE:SELect?
```

Returned Parameter

```
<NR1>, <NR1>
```

5.1.6.2. MOD:TABL

This command programs the user defined modulation table described in *Section 5.1.6.1, “ MOD:TYPE:SEL ”*. The feature allows the user to program non-linear output voltage and current

profiles to fit their application needs, such as source emulation or output adjustments with respect to an external sensor. Modulation functionality may be used either by issuing SCPI commands as detailed in this section or by entering the values into a table from the RIS Panel software as detailed in *Section 4.7, "Modulation Panel"*

The lookup table contains 4 columns and up to 50 rows; it stores an output profile as a function of the analog input voltage applied to terminal 25 of JS1, VMOD. As shown in *Table 5.4, "Modulation Table Parameters"*, the first column stores the table row and the second column sets an analog input VMOD. The third column store the Mod value associated with VMOD for that table row.

The fourth column of the lookup table, Loc, defines whether the table is stored in an active or temporary location. Certain applications may need to transition between different tables while the power supply is still running. For example, emulation of solar panel's voltage/current characteristics requires continuous external data acquisition along with quick and smooth table loading . The modulation subsystem provides two storage locations, Loc 0 or 1, to help improve table loading performance. With Loc set to 0, data will be stored to the Active Table, the table which is actively applied to the modulation function. With Loc set to 1, data will be stored to the Cache Table, the table intended to be accessed in the next in the profile. During the power on cycle, modulation tables stored in EPROM are copied into volatile RAM.

Modulation linearly interpolates between data points to form a piecewise-linear curve. Each column has to have data in an acceptable range. All tables less than 50 rows must be terminated with a VMOD value of 9999. Mod values at and past a row with VMOD of 9999 does not affect modulation.

Table 5.4. Modulation Table Parameters

	Column			
	1	2	3	4
Description	**Row**	**VMOD**	**Mod**	**Loc**
Acceptable Range	1 to 50	0.0 to 10.0	-1000.0 to 1000.0	0 to 1

While the table will store any value within the acceptable range, the power supply is limited by its output voltage and current specifications. For example, when using type 1 modulation, MOD:TYPE:SEL 1,1, a user can store a Mod value of -1000, but the power supply will only output a voltage down to 0 V. From row 1 to 50, VMOD has to be in ascending order.

Modulation points are read with two comma separated parameters, formatted as: Row, Loc. The query will return four parameters, formatted in the same way as the save table command above.

Command Syntax

```
MOD:TABL <NR1>(<NRF>,<NRF>,<NR1>)
```

Examples

```
MOD:TABL 12(0.13, 1.6, 1)
MODulation:TABLe 20(2.0, 15.002, 0)
MOD:TABL 13(1.5, -1.29, 0)
MOD:TABL 14(9999, 0, 1)
```

Query Syntax

```
MOD:TABL? <NR1>,<NR1>
```

Returned Parameter

```
<NR1>(<NRF>,<NRF>,<NR1>)
```

5.1.6.3. MOD:SAVE

This command copies the Active Table in RAM to a non-volatile, EEPROM memory. The Active Table, which is stored in RAM, loses its data on power down cycles. This command allows this data to be recovered at the power on cycle.

Command Syntax

```
MOD:SAVE
MODulation:TABLe:SAVE
```

Examples

```
MOD:SAVE
```

Related Commands

```
MOD:TABL:LOAD
```

5.1.6.4. MOD:TABL:LOAD

This command copies all data stored in the Cache Table to the Active Table. The command provides two optional parameters for initiating the activate set points for voltage and current. The command lets users quickly load tables and simultaneous change the power supply's output operating point.

Command Syntax

```
MOD:TABL:LOAD [<NRF>, <NRF>]
```

Examples

```
MOD:TABL:LOAD
MODulation:TABLe:LOAD
MODulation:TABL:LOAD 93.4, 30.3
```

Related Commands

```
MOD:SAVE
```

5.1.7. Output Commands

5.1.7.1. OUTP?

Description

This query returns the output state of the power supply. A 1 indicates the power supply is energized and a 0 indicates the power supply is off.

Query Syntax

```
OUTPut[:STATe]?
```

Examples

```
OUTP?
```

Returned Parameter

0 | 1

Related Commands

```
*RST, *RCL, *SAV
```

5.1.7.2. OUTP:ARM

Description

This command selects between the modes of operation. There are two modes of operation for the power supply: normal mode and auto sequence mode. Normal mode energizes the current parameters of the supply until stopped. Auto sequence mode sequentially steps through the memory updating the supply's parameters as it increments. Each memory location contains the voltage set point, current set point, over voltage trip, over current trip, and period. The period parameter specifies the time period for operating at the memory location when auto sequence operation is deployed. When enabled, the ARM light lights on the front panel.

To initiate a program sequence, select the starting memory location, execute this command, and issue an **OUPT:START** (see **OUTP:START**) or use the front panel start switch. The ARM light will blink after the start command. If this process reaches the upper memory limit, memory location 99, the following memory location will revert back to 0 and continue. Auto sequence operation will continue until an **OUTP:STOP** is commanded or a memory location with period set to 0 is encountered.

ARM? returns the arm state of the power supply unit.

Command Syntax

OUTP:ARM <bool>

Parameters

0 | OFF
1 | ON

Examples

OUTP:ARM OFF
OUTP:ARM 1

Query Syntax

OUTP:ARM

Returned Parameter

0 | 1

Related Commands

***RST, OUTP:START, OUTP:STOP**

5.1.7.3. OUTP:START

Description

This command closes the power supply's input contactor and initiates either normal or auto sequence mode. Auto sequence mode will be initiated if the **ARM** option is enabled. Normal mode energizes the power supply with the current parameters for voltage set point, current set point, over voltage trip, and over current trip. Auto sequence mode will sequentially step through memory locations until the stop is commanded, **OUTP:STOP**, or a terminating condition is reached (see **PER**, **OUTP:STOP**).

Command Syntax

OUTP:START

Examples

OUTP:START
OUTPUT:START

Related Commands

`*RST, OUTP:STOP, OUTP:ARM, PER`

5.1.7.4. OUTP:STOP

Description

This command opens the power supply's input contactor and initiates either normal or auto sequence mode.

Command Syntax

`OUTP:STOP`

Examples

`OUTP:STOP`
`OUTPUT:STOP`

Related Commands

`*RST, OUTP:START, OUTP:ARM, PER`

5.1.7.5. OUTP:PROT:CLE

Description

This command clears the alarm latches. There are seven alarm latches, namely: interlock, program line, phase balance, thermal, over voltage trip, over current trip, and input. When a fault is detected, the power supply is rendered to an alarm state. The power supply cannot be restarted until the protection condition is cleared and the latch is reset.

Command Syntax

`OUTPut:PROTection:CLEar`

Examples

`OUTP:PROT:CLE`
`OUTPUT:PROTECTION:CLEAR`

Related Commands

`*RST, *RCL, *SAV`

5.1.8. Source Commands

5.1.8.1. VOLT and VOLT:TRIG

Description

These commands set the power supply's immediate voltage level or the pending triggered voltage level. The immediate level is the voltage programmed for the immediate power supply output. The pending triggered level is a stored voltage value that is transferred to the power supply when a trigger occurs. A pending triggered level is unaffected by subsequent **`VOLT`** commands and remains in effect until the trigger subsystem receives a trigger or is aborted with an **`ABORt`** command. In order for **`VOLT:TRIG`** to be executed, the trigger subsystem must be initiated (see **`INIT`**).

`VOLT?` and **`VOLT:TRIG?`** return presently programmed immediate and triggered voltage levels. If no triggered level is programmed, then the voltage level is returned for both values. **`VOLT? MAX`** and **`VOLT? MIN`** return the maximum and minimum programmable immediate voltage levels.

VOLT:TRIG? MAX and **VOLT:TRIG? MIN** return the maximum and minimum programmable triggered voltage levels.

Command Syntax

```
[SOURce]:VOLTage[:LEVel][:IMMediate][:AMPLitude] <NRf+>
[SOURce]:VOLTage[:LEVel]:TRIGgered[:AMPLitude] <NRf+>
```

Examples

```
VOLT 200
VOLTAGE:LEVEL 200
VOLTAGE:LEVEL:IMMEDIATE:AMPLITUDE 2.5
VOLT:TRIG MAX
VOLTAGE:LEVEL:TRIGGERED 20
```

Query Syntax

```
[SOURce]:VOLTage[:LEVel][:IMMediate][:AMPLitude]?
[SOURce]:VOLTage[:LEVel][:IMMediate][:AMPLitude]? MAX
[SOURce]:VOLTage[:LEVel][:IMMediate][:AMPLitude]? MIN
[SOURce]:VOLTage[:LEVel]:TRIGgered[:AMPLitude]?
[SOURce]:VOLTage[:LEVel]:TRIGgered[:AMPLitude]?
[SOURce]:VOLTage[:LEVel]:TRIGgered[:AMPLitude]? MAX
[SOURce]:VOLTage[:LEVel]:TRIGgered[:AMPLitude]? MIN
```

Returned Parameter

```
<NR2>
```

Related Commands for VOLT

```
*SAV, *RCL, *RST
```

Related Commands for VOLT:TRIG

```
ABOR, VOLT, *RST
```

5.1.8.2. VOLT:PROT

Description

This command sets the over voltage trip (OVT) level of the power supply. If the output voltage exceeds the OVT level, then the power supply output is disabled and the Questionable Condition status register OV bit is set (see *Table 5.6, "Bit Configuration of the Questionable Register"*). An over voltage trip condition can be cleared with the **OUTP:PROT:CLE** command after the condition that caused the OVT trip is removed.

VOLT:PROT? returns presently programmed OVT level. **VOLT:PROT? MAX** and **VOLT:PROT? MIN**return the maximum and minimum programmable OVT levels.

Command Syntax

```
[SOURce]:VOLTage:PROTection[:LEVel] <NRf+>
```

Examples

```
VOLT:PROT 21.5
VOLTAGE:PROTECTION:LEVEL 145E-1
```

Query Syntax

```
[SOURce]:VOLTage:PROTection[:LEVel]?
[SOURce]:VOLTage:PROTection[:LEVel]? MIN
[SOURce]:VOLTage:PROTection[:LEVel]? MAX
```

Returned Parameter

<NR2>

Related Commands

OUTP:PROT:CLE, *RST, *SAV, *RCL

5.1.8.3. CURR and CURR:TRIG

Description

These commands set the immediate current level or the pending triggered current level of the power supply. The immediate level is the current programmed for the power supply output. The pending triggered level is a stored current value that is transferred to the power supply output when a trigger occurs. A pending triggered level is unaffected by subsequent **CURR** commands and remains in effect until the trigger subsystem receives a trigger or is aborted with an **ABORt** command. In order for **CURR:TRIG** to be executed, the trigger subsystem must be initiated (see **INITiate**)

CURR? and CURR:TRIG? return presently programmed immediate and triggered levels. If no triggered level is programmed, then the **CURR** level is returned for both values. **CURR? MAX** and **CURR? MIN** return the maximum and minimum programmable immediate current levels. **CURR:TRIG? MAX** and **CURR:TRIG? MIN** return the maximum and minimum programmable triggered current levels.

Command Syntax

[SOURce]:CURRent[:LEVel][:IMMediate][:AMPLitude] <NRf+>
[SOURce]:CURRent[:LEVel]:TRIGgered [:AMPLitude] <NRf+>

Examples

```
CURR 200
CURRENT:LEVEL MIN
CURRENT:LEVEL:IMMEDIATE:AMPLITUDE 2.5
CURR:TRIG 20
CURRENT:LEVEL:TRIGGERED 20
```

Query Syntax

[SOURce]:CURRent[:LEVel][:IMMediate][:AMPLitude]?
[SOURce]:CURRent[:LEVel][:IMMediate][:AMPLitude]? MAX
[SOURce]:CURRent[:LEVel][:IMMediate][:AMPLitude]? MIN
[SOURce]:CURRent[:LEVel]:TRIGgered[:AMPLitude]?
[SOURce]:CURRent[:LEVel]:TRIGgered[:AMPLitude]? MAX
[SOURce]:CURRent[:LEVel]:TRIGgered[:AMPLitude]? MIN

Returned Parameter

<NR2>

Related Commands

***SAV, *RCL, *RST**

Related Commands

ABOR, CURR, *RST

5.1.8.4. CURR:PROT

Description

This command sets the over current trip (OCT) level of the power supply. If the output current exceeds the OCT level, then the power supply output is disabled and the Questionable Condition status register OC bit is set (see *Table 5.6, "Bit Configuration of the Questionable Register"*). An over current trip condition can be cleared with the **OUTP:PROT:CLE** command after the condition that caused the OCT trip is removed.

CURR:PROT? returns presently programmed OCT level. **CURR:PROT? MAX** and **CURR:PROT? MIN** return the maximum and minimum programmable OCT levels.

Command Syntax

[SOURce]:CURRage:PROTection[:LEVel] <NRf+>

Examples

CURR:PROT MAX CURRENT:PROTECTION:LEVEL 145E-1

Query Syntax

[SOURce]:CURRent:PROTection[:LEVel]?
[SOURce]:CURRent:PROTection[:LEVel]? MIN
[SOURce]:CURRent:PROTection[:LEVel]? MAX

Returned Parameter

<NR2>

Related Commands

OUTP:PROT:CLE, *RST, *SAV, *RCL

5.1.8.5. PER

Description

This command is available on TS Series, MS Series, and MT Series programmable DC power supplies with the D Version front panel. This command sets the period of time that the power supply will remain in the state during auto sequence operation. The minimum unit for the period command is 10 msec and the maximum unit is 9997 sec. There are 3 reserved numbers associated with this command, namely: 0, 9998 and 9999. When a 0 is detected in auto sequence operation, the power supply will stop as if a stop command condition (see **OUTP:STOP**)occurred. When a 9998 is detected, the following memory location will be zero. When 9999 is detected, the power supply will operate at that memory state indefinitely or until stop (see **OUTP:STOP**) is commanded. The period's duration can be overridden by using the start command (see **OUTP:START**) to advance the memory to the next state or the stop command (see **OUTP:STOP**) to stop the power supply.

Command Syntax

[SOURce]:PERiod <NRf+>

Examples

SOUR:PER 200
SOURCE:PERIOD 1345
SOUR:PER MAX

Query Syntax

[SOURCE]:PERiod?
[SOURCE]:PERiod? MIN
[SOURCE]:PERiod? MAX

Returned Parameter

<NR1>

Related Commands

***RST, OUTP:START, OUTP:STOP, OUTP:ARM**

5.1.8.6. REC:MEM

Description

The recall command sets the current memory location of the power supply. In remote mode, 100 (0 - 99) memory locations are available for programming. In local mode, the 10 (0 - 9) memory locations are available for programming.

Command Syntax

[RECall]:MEMory <NR1>

Examples

REC:MEM 10
MEM 99

Query Syntax

RECall:MEMory?

Returned Parameter

<NR1>

Related Commands

***RCL, *SAV**

5.1.9. Status Commands

5.1.9.1. STAT:OPER:COND?

Description

This query returns the value of the Operation Register which is a read-only register that holds the real-time (unlatched) condition of the operational status of the power supply. The bit configuration of the Operation Register is shown in *Table 5.5, "Bit Configuration of the Operation Register"*.

Query Syntax

STATus:OPERation:CONDition?

Examples

STAT:OPER:COND?
STATUS:OPERATION:CONDITION?

Returned Parameter

<NR1> (Register value)

Table 5.5. Bit Configuration of the Operation Register

Bit	Weight	Abbreviation	Description
0	1	ARM	Arm
1	2	SS	Soft Start
2	4	LOCK	Locked

Bit	Weight	Abbreviation	Description
3	8	INT	Internal Control
4	16	EXT	External Control
5	32	WTG	Interface is Waiting for Trigger
6	64	STBY	Standby
7	128	PWR	Power
8	256	CV	Constant Voltage
9	512	RSEN	Remote Sense
10	1024	CC	Constant Current
11	2048	STBY/ALM	Standby or Alarm
12-15		NU	Not Used

5.1.9.2. STAT:QUES:COND?

Description

This query returns the value of the Questionable Register. The Questionable Register is a read-only register that holds the real-time (unlatched) condition of the questionable status of the power supply. The bit configuration of the Questionable Register is shown in the *Table 5.6, "Bit Configuration of the Questionable Register"*.

Query Syntax

`STATus:QUEStionable:CONDition?`

Examples

`STAT:QUES:COND?`
`STATUS:QUESTIONABLE:CONDITION?`
`SOUR:PER MAX`

Returned Parameter

`<NR1>` (Register value)

Table 5.6. Bit Configuration of the Questionable Register

Bit	Weight	Abbreviation	Description
0	1	OV	Over Voltage Tripped
1	2	OC	Over Current Tripped
2	4	PB	Phase Balance Protection Tripped
3	8	PGM	Program Line Protection Tripped
4	16	OT	Over Temperature Protection Tripped
5	32	FUSE	Fuse Protection Tripped
6	64	NU	Not Used
7	128	ALM	Alarm Protection Tripped
8	256	ILOC	Interlock
9	512	REM	Remote
10-15		NU	Not Used

5.1.10. System Commands

5.1.10.1. SYST:VERS?

Description

The **SYST:VERS?** query returns the firmware and hardware version of the power supply. The returned value has the form Firmware Rev. X.X, Hardware Rev. X.X.

Query Syntax

SYSTem:VERSion?

Examples

SYST:VERS?
SYSTEM:VERSION?

Returned Parameter

<Firmware Rev. XX.Y, Hardware Rev. XX.Y>

5.1.10.2. SYST:ERR?

Description

The **SYST:ERR?** query returns the error messages that have occurred in the system. The format of the return string is an error number followed by corresponding error message string. The errors are stored in a FIFO (first-in, first-out) buffer. As the errors are read, they are removed from the queue. When all errors have been read, the query returns 0, "NO ERROR." If more errors have accumulated than the queue can hold, the last error in the queue will be -350, "Queue Overflow." When system errors occur, the Standard Event Status Register (ESR), records the error groups as defined in *Table 5.7, "Standard Event Status Register Error Bits"*. *Table 5.8, "Error Messages"* lists system errors that are associated with SCPI syntax errors and with interface problems.

Table 5.7. Standard Event Status Register Error Bits

Bit	Error Code	Error Type
5	100 through -199	Command
4	200 through -299	Execution
3	300 through -399	Device dependent
2	400 through -499	Query

Table 5.8. Error Messages

Error	Error String	Error Description
-100	Command error	Generic command error
-102	Syntax error	Unrecognized command or data type
-108	Parameter not allowed	Too many parameters
-222	Data out of range	E.g., outside the range of this device
-350	Queue overflow	Errors lost due to too many errors in queue
-400	Query error	Generic query error

Query Syntax

SYSTem:ERRor?

Examples

SYST:ERR?
SYSTEM:ERROR?

Returned Parameter

<error number>, <error string>

5.1.11. Trigger Commands

5.1.11.1. TRIG

Description

This command controls remote triggering of the power supply. When the trigger subsystem is enabled, a **TRIG** command generates a trigger signal. The trigger signal will then initiate a pending level change as specified by **CURR[:LEV]:TRIG** or **VOLT[:LEV]:TRIG**. Afterwards, the Operation Register will be cleared. If **INIT:CONT** is on, the trigger subsystem is immediately re-enabled for subsequent triggers. As soon as it is cleared, the **WTG** bit is again set to 1.

Command Syntax

TRIGger[IMMediate]

Examples

TRIG
TRIGGER:IMMEDIATE

Related Commands

ABOR, CURR:TRIG, INIT, *TRG, VOLT:TRIG

5.1.11.2. INIT

Description

This command enables the trigger system. When the initiate command is enabled, a **TRIG** command allows specified triggering action to occur. If the initiate subsystem is not enabled, all trigger commands are ignored. If **INIT:CONT** is OFF, then **INIT** enables the trigger subsystem only for a single trigger action; **INIT** must then be repeated prior to further trigger commands. If **INIT:CONT** is ON, then the trigger subsystem is continuously enabled.

INIT:CONT? returns the state of the continuous trigger mode.

Command Syntax

INITiate[:IMMediate]
INITiate:CONTinuous <bool>

Parameters for INIT[:IMM]:

None

Parameters for INIT:CONT:

0 | OFF
1 | ON

Examples

INIT
INITIATE:IMMEDIATE
INIT:CONT 1

INITIATE:CONTINUOUS OFF

Query Syntax for INIT[:IMM]:
None

Query Syntax for INIT:CONT:
INIT:CONT?

Returned Parameter
0 | 1

Related Commands
ABOR, *RST, TRIG

5.1.11.3. ABORt

Description
This command cancels any trigger actions presently in process. Any pending trigger levels are reset to their immediate values. **ABORt** also resets the **WTG** bit in the Operation Register. If initiate continuous is enabled **(INIT:CONT ON)**, the trigger subsystem immediately re-initiates itself after **ABORt**, thereby setting **WTG**. **ABOR** is executed at power turn on and upon execution of ***RCL** or ***RST**.

Command Syntax
ABORt

Examples
ABOR

Related Commands
INIT, TRIG, *RCL, *RST

5.2. RS232 Communications

All Magna-Power Electronics products come standard with RS232 communications, which provides the simplest means to communicate with the power supply. The RS232 configuration settings are detailed in *Table 5.9, "RS232 Interface Configuration"*. The RS232 terminal, connector JS3, is detailed in *Table 5.10, "RS232 Terminal Definition, Connector JS3"*. All the commands detailed in *Section 5.1, "SCPI Commands"* are supported over RS232.

Note

When using external converters that utilize the RS232 port, the settings from *Table 5.9, "RS232 Interface Configuration"* **must** be used or the product will not communicate.

Table 5.9. RS232 Interface Configuration

Parameter	Value
Baud Rate	19200
Data Size	8-bit
Parity	None

Parameter	Value
Stop Bits	1
Flow Control	Off
Cable Type	Straight-through

Table 5.10. RS232 Terminal Definition, Connector JS3

Pin	Definition
1	NC
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	NC

5.3. IEEE-488 GPIB Communications

XR Series III power supplies are available with an optional IEEE-488 GPIB interface. When specified at time of order, an IEEE-488 GPIB interface module is installed internally to make a second UART port available for communications. With two UART ports available, RS232 and IEEE-488 GPIB, the one first receiving communications after power on is the port that is activated. Once activated, the other UART port cannot be recognized unless there has been a period of inactivity for 5 minutes. After this period, a new UART port can be recognized by sending communications. The IEEE-488 GPIB terminal, connector JS4, is detailed in *Table 5.11, "IEEE-488 GPIB Terminal Definition, Connector JS4"*.

Table 5.11. IEEE-488 GPIB Terminal Definition, Connector JS4

Pin	Definition	Pin	Definition
1	DIO1/Data line	13	DIO5/Data line
2	DIO2/Data line	14	DIO6/Data line
3	DIO3/Data line	15	DIO7/Data line
4	DIO4/Data line	16	DIO8/Data line
5	EOI/End or Identify	17	REN/Remote Enable
6	DAV/Data Valid	18	DAV/Gnd
7	NRFD/Not Ready for Data	19	NRFD/Gnd
8	NDAC/Not Data Accepted	20	NDAC/Gnd
9	IFC/Interface Clear	21	IFC/Gnd
10	SRQ/Service Request	22	SRQ/Gnd
11	ATN/Attention	23	ATN/Gnd
12	Shield	24	Gnd

All of the SCPI subsystem commands in the previous section can be initiated using RS232, optional IEEE-488 GPIB (+GPIB), or optional LXI TCP/IP Ethernet (+LXI) communications.

The IEEE-488 standard defines a method for status reporting. As illustrated in figure 4.1, the method uses the IEEE-488.1 Status Byte (STB). Three bits of this byte are defined as: Master Status Summary (MSS) Bit, Event Status Bit (ESB), and Message Available (MAV) Bit.

The Master Status Summary (MSS) is an unlatched bit. When the Status Byte Register is read using a Status Byte Register query, bit 6 will be 1 if there are any conditions requiring service.

The STB is masked by the Service Request Enable Register (SRE) to allow the user to mask specific or all events from setting the MSS bit to 1. The MSS bit is obtained by logical OR'ing the bits of the enabled Status Byte Register.

The Event Status Bit (ESB) is set when one of the events defined in the Event Status Register (ESR) *Table 5.12, "Event Status Register"* has occurred. Like the STB, the ESR is masked by the Event Status Enable Register (ESE) to allow the user to mask specific or all events from setting the ESB to 1.

The Message AVailable (MAV) bit is set to 1 when a message is available in the output buffer.

5.3.1. IEEE-488 GPIB Communication using the Remote Interface Software

Chapter 4, Remote Interface Software describes application of the Remote Interface Software which is shipped with XR Series III power supplies. This software provides the user with a quick method to operate a Magna-Power Electronics power supply under computer control. The software can be configured for a number of communication interfaces; IEEE-488 GPIB is included as one of these interfaces.

To use the Remote Interface Software with optional IEEE-488 GPIB communications, the address, 1 to 30, defined in the Remote Interface Software and the address encoded in the power supply must match. Address 0 is assigned to the GPIB master. The default programmable DC power supply address is 1, but if the address is unknown, press Find Device in the Communication Setup menu. The routine scans all the devices on the bus providing their addresses and identifications. Select the desired device and press OK; this automatically changes the address in the Communication Setup. The same result can be achieved with a double click on the desired device. After communications is established, the address of the device may be changed by pressing Change Device's Settings.

5.3.2. IEEE-488 GPIB Communications with MAX

National Instruments offers Measurement and Automation Explorer (MAX), a Graphical User Interface, as a terminal emulation program for configuring an Interchangeable Virtual Instrument (IVI). MAX is usually installed with one of National Instrument's Application Development Environments such as LabVIEW, Measurement Studio, or with hardware product drivers such as NI-488 and NI-DAQ.

To operate the power supply with MAX, the instrument must first be located for communications. The following steps describe this procedure.

1. Run the MAX application program.
2. In the Configuration window, press the + sign to the left of Devices and Interfaces to view the installed devices.
3. If there is more than one IEEE-488 GPIB device listed, then select the correct GPIB device.
4. Press Scan for Instruments on the menu bar and wait several seconds.
5. At least one instrument should appear under the GPIB controller. If no instruments appear, then refer to *Section 5.3, "IEEE-488 GPIB Communications"* to verify the correct setup.

6. On the menu bar, press Communicate with Instrument. The NI-488 Communicator dialog box should appear.
7. In the NI-488 Communicator dialog box, press the Configure EOS button. The Termination Method dialog box should appear.
   - Select the option Send EOI at end of Write.
   - Enter 0 into th EOS byte.
   - Press OK.

5.3.3. IEEE-488 GPIB SCPI Commands and Registers

5.3.3.1. GPIB:VERS?

Description

This query is available only for units with the IEEE-488 GPIB (+GPIB) option installed. This query reads the firmware version of the GPIB communication module.

Query Syntax

[SYSTem][:COMMunicate]:GPIB:VERSion?

Examples

SYST:COMM:GPIB:VERS?
GPIB:VERS?

Returned Parameter

<Firmware Ver. XX.Y>

5.3.3.2. GPIB:ADDR

Description

This command is available only for units with the IEEE-488 GPIB (+GPIB) option installed. This command sets the address of the GPIB module of the power supply. The address can be 1 to 30 where address 0 is normally assigned to the GPIB Master. The factory default address is 1.

Command Syntax

[SYSTem][:COMMunicate]:GPIB:ADDRess <NR1>

Parameters

1 - 30

Examples

SYST:COMM:GPIB:ADDR 27
GPIB:ADDR 27

Query Syntax

[SYSTem][:COMMunicate]:GPIB:ADDR?

Returned Parameter

<NR1>

5.3.3.3. Clear

Description

This command clears all status register (**ESR**, **STB** and error queue).

Command Syntax

`*CLS <>`

Related Commands

`*RST`

5.3.3.4. Read Event Status Register

Description

This query reads the Event Status Register (ESR). After reading the ESR, the register is cleared. The bit configuration of the ESR is the same as the Event Status Enable Register (**`*ESE`**). The return parameter is weighted as shown in *Table 5.12, "Event Status Register"*.

The Power On Bit (PON) is set every time the power supply is reset. It can be used to detect a power outage or power supply reset.

Query Syntax

`*ESR?`

Example

`*ESR?`

Return Parameter

`<NR1>` (Register value)

Related Commands

`*CLS, *ESE, *ESE?`

Table 5.12. Event Status Register

Bit	Weight	Abbreviation	Description
0	1	OPC	Operation Complete
1	2	NU	Not Used
2	4	QYE	Query Error
3	8	DDE	Device Dependent Error
4	16	EXE	Execution Error
5	32	CME	Command Error
6	64	NU	Not Used
7	128	PON	Power On Event, 1 after power on

5.3.3.5. Read and Set Event Status Enable Register

Description

This command programs the Event Status Enable Register (ESE). The programming determines which events of the Event Status Register (ESR) set the Event Status Bit (ESB) of the Status Byte Register (STB). A "1" in the bit position enables the corresponding event. All of the enabled events of the ESE are logically OR'd to cause the ESB of the STB to be set.

Command Syntax

`*ESE <NR1>`

Example

`*ESE 255`

Query Syntax

`*ESE?`

Return Parameter

`<NR1>`

Related Commands

`*ESR?, *STB?`

5.3.3.6. Read Status Byte Register

Description

This query reads the Status Byte Register (STB), defined in *Table 5.13, "Status Byte Register"*, which contains the Master Status Summary (MSS) bit, Event Status (ESB) bit, and the Message Available (MAV) bit. Unlike reading ESR, the STB is not cleared after it is read. The MAV bit is cleared at power on or by **`*CLS`**.

Query Syntax

`*STB?`

Example

`*STB?`

Return Parameter

`<NR1>` (Register value)

Related Commands

`*ESR?, *ESE`

Table 5.13. Status Byte Register

Bit	Weight	Abbreviation	Description
0	1	NU	Not Used
1	2	NU	Not Used
2	4	NU	Not Used
3	8	NU	Not Used
4	16	MAV	Message Available
5	32	ESB	Event Status Bit
6	64	NU	Not Used
7	128	NU	Not Used

5.3.3.7. Read and Set Service Request Enable Register

Description

This command sets the Service Request Enable Register (SRE). This register, defined in *Table 5.14, "Service Request Enable Register"*, determines which bits from the Status Byte Register (see *STB for its bit configuration) are allowed to set the Master Status Summary (MSS)

Bit. A 1 in any SRE bit position enables the corresponding Status Byte Register bit. All Status Byte Register enabled bits are then logically OR'd and placed in bit 6 of the Status Byte Register. When *SRE is cleared (by programming it with 0), the power supply cannot generate a service request to the controller.

Command Syntax

`*SRE <NR1>`

Example

`*SRE 20`

Query Syntax

`*SRE?`

Return Parameter

`<NR1>` (Register value)

Related Commands

`*ESR, *ESE`

Table 5.14. Service Request Enable Register

Bit	Weight	Abbreviation	Description
0	1	NU	Not Used
1	2	NU	Not Used
2	4	NU	Not Used
3	8	NU	Not Used
4	16	MAV	Message Available
5	32	ESB	Event Status Bit
6	64	MSS	Master Summary
7	128	NU	Not Used

5.3.3.8. Read Model Number, Part Number, and Serial Number

Description

This query requests the power supply to identify itself. It returns a string composed of three fields separated by commas

Query Syntax

`*IDN?`

Return Parameter

Company Name, Power Supply Model, S/N (string format)

Example

Magna-Power Electronics Inc., XR16-375, S/N: 1162-0361, F/W:1.0

Related Commands

`CALibrate:IDN`

5.3.3.9. Save

Description

This command is available for all SL Series and XR Series models, and TS Series, MS Series, and MT Series units with the D Version front panel. This command stores the present state of the power supply at the specified location in memory. Data can be saved in 100 memory locations. The following power supply parameters are stored by *SAV:

VOLT[:LEV][:IMM]
CURR[:LEV][:IMM]
VOLT:PROT[:LEV]
CURR:PROT[:LEV]
PER

Command Syntax

***SAV <NR1>**

Parameters

0 - 99

Example

***SAV 1**

Related Commands

***RCL, MEM**

5.3.3.10. Recall

Description

This command restores the power supply to a state that was previously stored in memory location with a ***SAV** command. The ***RCL** command can recall data in 100 memory locations. For XR Series programmable DC power supply, only memory location 0 is available. The following parameters are recalled:

VOLT[:LEV][:IMM]
CURR[:LEV][:IMM]
VOLT:PROT[:LEV]
CURR:PROT[:LEV]
PER

The ***RCL** command forces an **ABORt** command before resetting any parameters. **ABOR** cancels any trigger actions presently in progress and sets **INIT:CONT** to OFF.

At power turn-on, recall is commanded at the memory location prior to turn-off state.

Command Syntax

***RCL <NR1>**

Parameters

0 - 99

Example

***RCL 1**

Related Commands

***RST, *SAV**

5.3.3.11. Reset

Description

This command resets the power supply to factory default states as defined below:

```
OUTP[:STAT] OFF
CURR[:LEV][:IMM] 0
CURR[:LEV]:TRIG 0
VOLT[:LEV][:IMM] 0
VOLT[:LEV]:TRIG 0
PER 0
INIT:CONT OFF
VOLT:PROT[:LEV] 110% of MAX
CURR:PROT[:LEV] 110% of MAX
```

***RST** also forces an **ABORt** command.

Command Syntax

***RST <>**

5.4. LXI TCP/IP Ethernet Communications

XR Series III power supplies are available with an optional LXI TCP/IP Ethernet interface. The optional LXI TCP/IP Ethernet interface meets the LXI Class C, Revision 1.2 standard. When specified at time of order, an Ethernet interface module is installed to make a second UART port available for communications. With two UART ports available, RS232 and Ethernet, the one first receiving communications after power on is the port that is activated. Once activated, the other UART port cannot be recognized unless there has been a period of inactivity for 5 minutes. After this period, a new UART port can be recognized by sending communications. **By default, DHCP is enabled on the power supply.** In the absence of a DHCP server, the power supply will default to the settings defined in *Table 5.15, "Default LXI TCP/IP Ethernet settings (without DHCP Server)"*. The LXI TCP/IP Ethernet interface, connector JS5, is detailed in *Table 5.16, "LXI TCP/IP Ethernet Terminal Definition, JS5"*

Table 5.15. Default LXI TCP/IP Ethernet settings (without DHCP Server)

Parameter	Value
IP Address	169.254.###.###
Subnet Mask	255.255.0.0
Default Gateway	0.0.0.0
DNS Server	0.0.0.0
MAC Address	01:1E:6F:##:##:##

Table 5.16. LXI TCP/IP Ethernet Terminal Definition, JS5

Pin	Definition
1	TX+
2	TX-
3	RX+
4	NC
5	NC
6	RX-
7	NC

Pin	Definition
8	NC

Ethernet communications can be made though the Remote Interface Software, a terminal emulation programs like Microsoft Windows (tm) HyperTerminal Program, 3rd party software, or through a computer's web page browser. In the latter case, software, programmed into the LXI TCP/IP Ethernet interface module, allows the power supply to be recognized and to communicate directly with the computer without the need for additional programs stored in the computer.

An IVI-COM Driver is included with the installation CD and is available for download from the Magna-Power Electronics' web page. The driver allows the power supply to communicate through many different programming languages. The driver handles the low-level bus protocols simplifying automation development. It supports TCP/IP, GPIB, and RS232 using standard VISA resource descriptors. For additional documentation and details on using the IVI-COM driver, see *Section 5.7, "IVI-COM Driver"*.

5.4.1. Connectivity and IP Address Negotiation

When the LXI TCP/IP Ethernet module is configured for DHCP, but the DHCP server cannot be located, the module falls back to an Auto-IP configuration. The device then automatically selects an IP address from 169.254.###.### subnet as described in RFC 3927 (Request for Comments 3927 - Dynamic Configuration of IPv4 Link-Local Addresses). This routine is the same as that used with operating systems such as Microsoft Windows. This allows the user to use the LXI TCP/IP Ethernet interface in the absence of a DHCP server.

The LAN status LED, located at the rear of the power supply, provides LAN fault and device identification as defined as follows:

- On – Normal Operation. The device has a properly configured IP address and the network cable is connected.
- Flashing – Device Identify. The LXI Device Identification function was enabled via the Instrument Identification web page. This identification can help the user to quickly locate the unit and distinguish it from similar devices.
- Off – LAN Fault. The device is experiencing one or more of the following LAN fault conditions: failure to acquire a valid IP address, detection of a duplicate IP address on the network, failure to renew an already acquired DHCP lease, or the LAN cable is disconnected.

The LAN Reset button provides a way to reset the LAN configuration password and to set the device back to DHCP/Auto-IP mode. To activate the LAN Reset function, ensure the power supply is on and in standby mode. Hold down the LAN Reset button for approximately 4 seconds. Observe that the LAN LED rapidly flashes and after 4 seconds, release the LAN Reset button. The LAN configuration password will be reset to blank and the module will be set to DHCP/Auto-IP enabled.

The MAC address consists of two number groups, in format: ##:##:##:##:##:##. For Magna-Power Electronics products, the first three bytes are always **`01:1E:6F`**. The second three bytes are determined by the the LXI TCP/IP Ethernet interface's serial number, converted to hex. This serial number can be queried from the power supply using the SCPI command **`SYSTem:COMMunicate:NETwork:SERial`**.

The LXI TCP/IP Ethernet module supports the VXI-11 discovery protocol allowing the device to be discovered on the network by software such as National Instruments Measurement and Automation Explorer, Agilent Connection Expert, or the Remote Interface Software supplied with the power supply.

5.4.2. LXI TCP/IP Ethernet Control and Discovery Methods

The Ethernet module supports the VXI-11 discovery protocol allowing the device to be discovered on the network by software such as National Instruments' Measurement and Automation Explorer, Agilent Connection Expert, or the Remote Interface Software supplied with the power supply.

5.4.2.1. Remote Interface Software

Chapter 4, Remote Interface Software describes application and configuration of the Remote Interface Software which is shipped with XR Series III programmable DC power supply. This software provides the user with a quick method to operate a Magna-Power Electronics' power supply under computer control. The software can be configured for a number of communication interfaces; Ethernet is included as one of these interfaces.

To use the Remote Interface Software with optional Ethernet communications, the address parameters in the Remote Interface Software and that encoded in the power supply must match. The factory default for DHCP is 1 (on) allowing the IP address to be automatically set by the DHCP server on the network. If DHCP is off and the address is unknown, the device can be located using the Remote Interface Software supplied with the power supply. To access discovery, press Find Device in the Communication Setup menu. The routine scans all the devices on the network and provides their addresses and identifications. Select the desired device and press OK; this automatically changes the address in the Communication Setup. The same result can be achieved with a double click on the desired device. After communications is established, the address of the device may be changed by pressing Change Device's Settings.

5.4.2.2. Web Browser

The LXI TCP/IP Ethernet interface has an embedded web server that allows the user to view and change the module's network settings and provides basic control of the power supply. Magna-Power Electronics LXI TCP/IP Ethernet interface is LXI Class C compliant under LXI Standard Revision 1.2.

To access the web server, first determine the module's IP address via one of the discovery methods described in *Section 5.4.2.1, "Remote Interface Software"*. Alternatively, if the host computer supports NetBIOS over TCP/IP, you may use the device's NetBIOS name instead of the IP address.

Open a WC3 compliant web browser such as Microsoft Internet Explorer, Firefox, or Opera to http://[ipaddress]/ or http://[name]/. The instrument information screen will be displayed as shown in *Figure 5.1, "Web interface information panel"*. This figure provides the basic information about the configuration and allows the user to enable or disable the LXI Identification. Click Enable Identify or Disable Identify to change the state of the LXI Identification. When LXI Identification is enabled, the LAN LED on the back of the power supply unit will blink. This can help the user to quickly locate the power supply and distinguish it from similar devices.

To change the Ethernet interface's network settings, click the Configure tab in the upper right. The browser will prompt for a username and password if you have not authenticated the device already. To authenticate, enter admin for the username and leave the password field blank. The instrument configuration screen, *Figure 5.2, "Web interface configure panel"*, will appear. This page enables the user to change the Hostname (which corresponds to the NetBIOS name), the description, password, and TCP/IP configuration. After changes to the configuration are made, click the Save Config button. The configuration will be saved, the Ethernet interface will reboot and instructions will be displayed for reconnecting to the interface.

Web control of the power supply requires Adobe Flash Player which is available for download from http://get.adobe.com/flashplayer/. To control the power supply, click the Control tab in the upper right. The browser may prompt for a username and password if you have not authenticated the device

already. To authenticate, enter admin for the username and leave the password field blank. The power supply's control panel will be displayed. The screen displays the same status information as the front panel of the power supply and allows the user to control and read voltage, current, over voltage trip, over current trip, mode of operation, and diagnostics. Like the front panel, a diagnostic condition can be cleared using the clear button. Only one user can control the power supply at a time with the Remote Interface Software or the web interface.

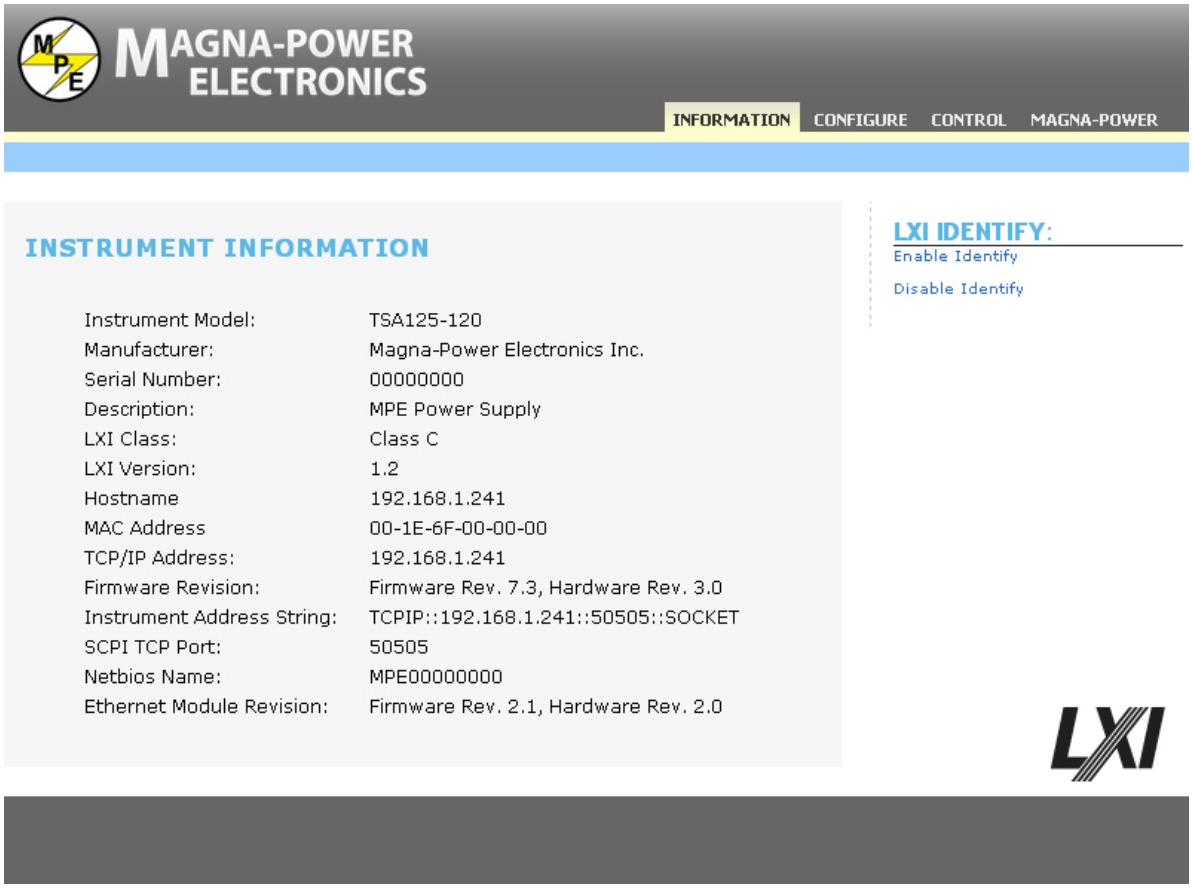

Figure 5.1. Web interface information panel

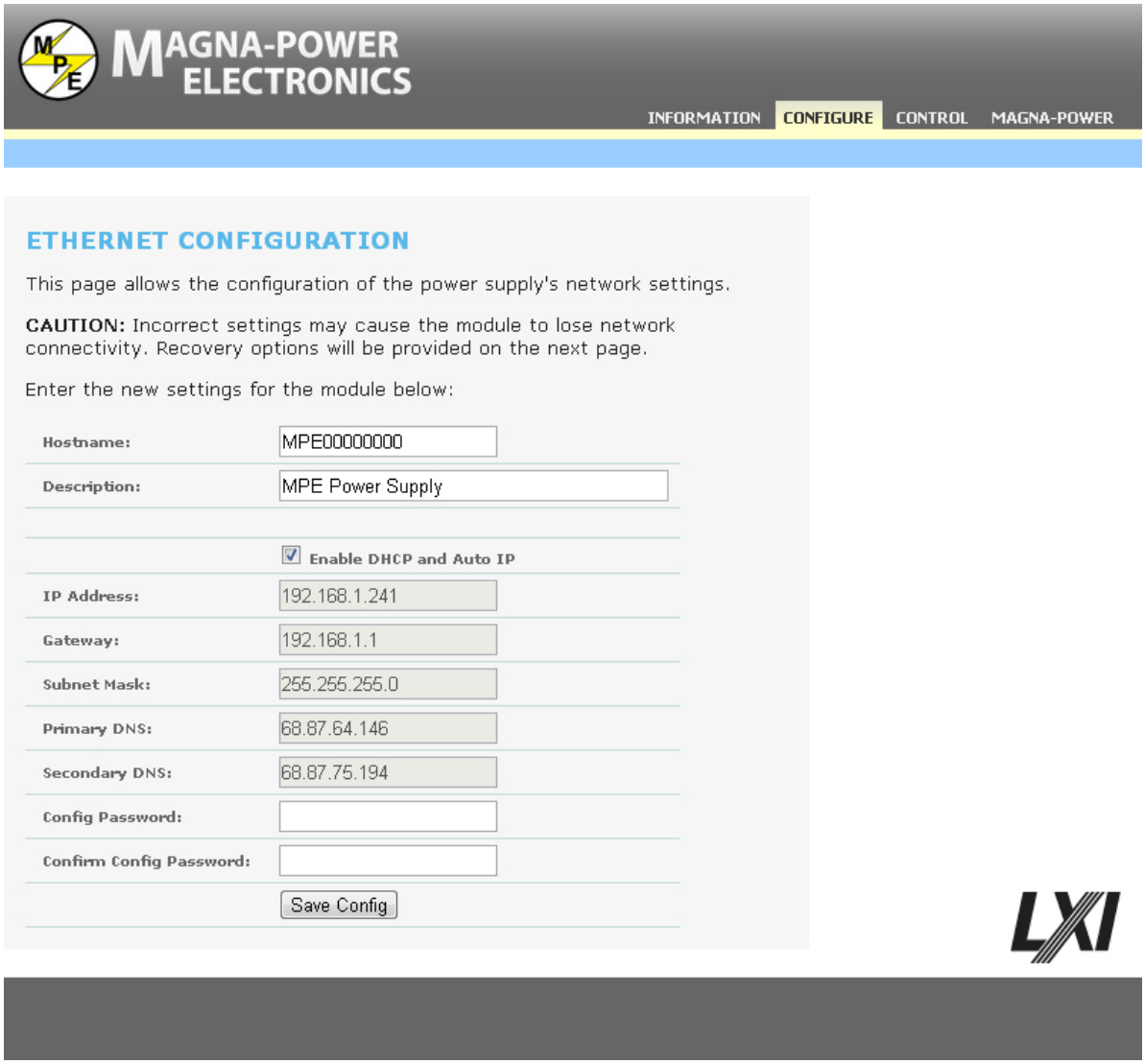

Figure 5.2. Web interface configure panel

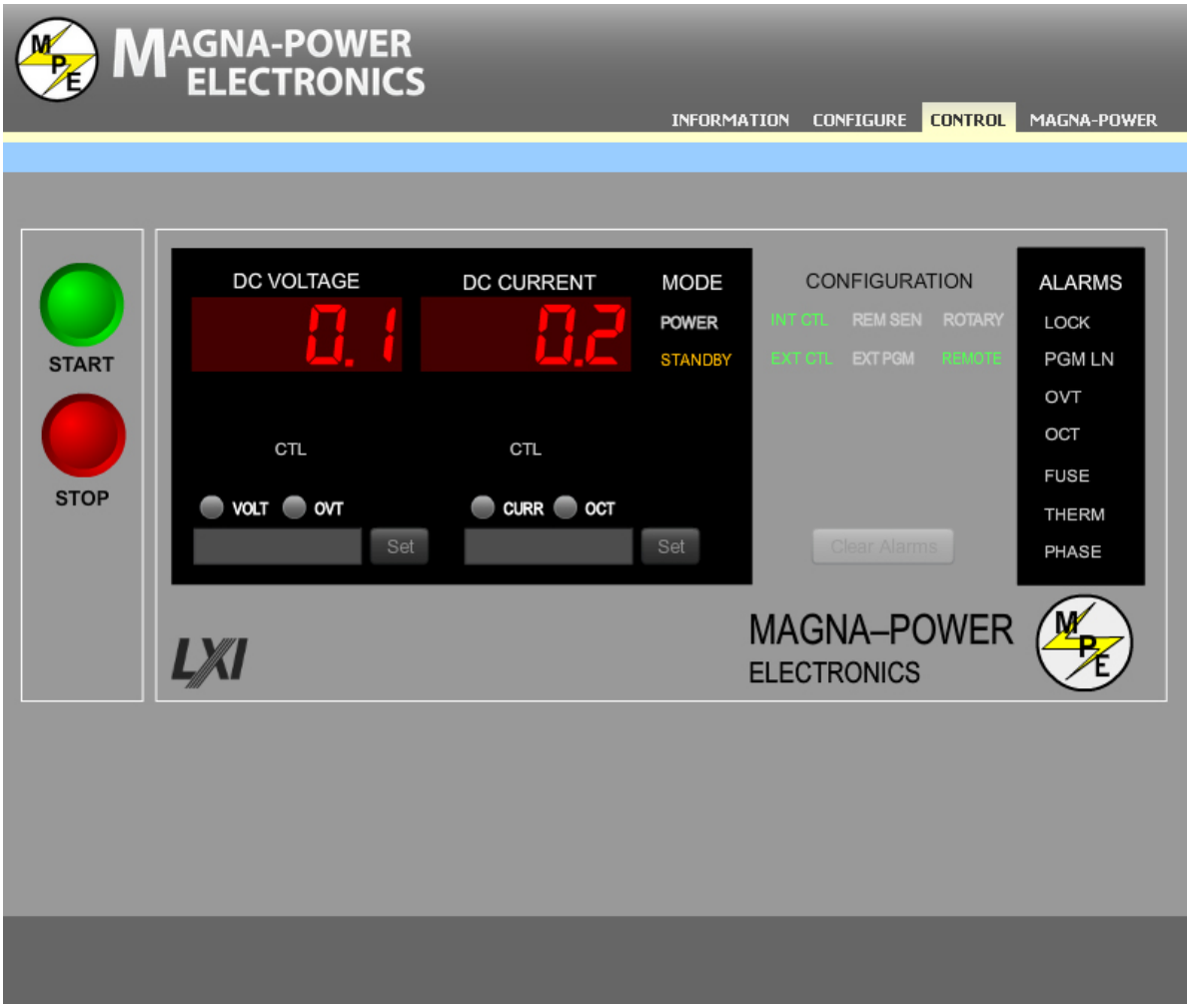

Figure 5.3. Web interface control panel

5.4.2.3. Discovery using NI Measurement and Automation Explorer

To access discovery with NI Measurement and Automation Explorer, the NI-VISA add-on module must be installed along with the standard software package. Start NI Measurement and Automation Explorer, right-click on Devices and Interfaces, and then select "Create New…" Select "VISA TCP/IP Resource" from the list. Click Next and then select Auto-detect of LAN Instrument. Click Next and the software will scan the local network for VXI devices and display them for configuration for further usage with NI-VISA and related software.

5.4.2.4. Discovery using Agilent Connection Expert

To access discovery with Agilent Connection Expert, start Agilent Connection Expert. Select your computer's LAN interface and then click the Add Instrument button at the top of the screen. The software will scan the local network for VXI devices and display them for configuration for further use with Agilent VISA compatible software.

5.4.2.5. HyperTerminal

The following procedure outlines using Microsoft Windows (tm) HyperTerminal Program to communicate using the LXI TCP/IP Ethernet communications.

1. Start the HyperTerminal application and when prompted select "TCP/IP (Winsock)" in the "Connect using" list box.

2. Insert the recorded IP address in the "Host address" text box and port number in the "Port number" text box.
3. Click the "OK" button.
4. Set the following properties for HyperTerminal's ASCII setup:
   - Send line ends with line feeds.
   - Echo typed characters locally.
   - Append line feeds to incoming line ends.
5. Type "*IDN?" in the input window and press enter. The identification of the instrument should appear.

5.4.3. LXI TCP/IP Ethernet SCPI Commands

5.4.3.1. NET:VERS?

Description

This query reads the firmware and hardware versions of the Ethernet communications module.

Query Syntax

[SYSTem][:COMMunicate]:NETwork:VERSion?

Examples

SYST:COMM:NET:VERS?
NET:VERS?

Returned Parameter

<Firmware Ver. XX.Y, Hardware Rev. XX.Y>

5.4.3.2. NET:MAC?

Description

This query returns the MAC address of the Ethernet module. MAC address consist of two number groups: the first three bytes are known as the Organizationally Unique Identifier (OUI), which is distributed by the IEEE, and the last three bytes are the device's unique serial number. The six bytes are separated by hyphens. The MAC address is unique to the instrument and cannot be altered by the user.

Query Syntax

[SYSTem][:COMMunicate]:NETwork:MAC?

Examples

SYST:COMM:NET:MAC?
NET:MAC?

Returned Parameter

<XX-XX-XX-YY-YY-YY>

Related Commands

NET:ADDR, NET:GATE, NET:SUBN, NET:PORT, NET:HOST, NET:DHCP

5.4.3.3. NET:SER?

Description

This command sets the serial number of the Ethernet module. The serial number is an integer ranging from 1 to 16777215 and cannot be altered by the user.

Query Syntax

[SYSTem][:COMMunicate]:NETwork:SER?

Examples

SYST:COMM:NET:SER?
NET:SER?

Returned Parameter

<NR1>

5.4.3.4. NET:ADDR

Description

This command sets the static address of the Ethernet module of the power supply. The factory default address setting is 192.168.1.100.

Command Syntax

[SYSTem][:COMMunicate]:NETwork:ADDRess <string>

Parameters

IP address is represented with 4 bytes each having a range of 0-255 separated by periods

Examples

SYSTem:COMM:NET:ADDR 192.168.10.2
NET:ADDR 192.168.10.2

Query Syntax

[SYSTem][:COMMunicate]:NETwork:ADDRess?

Returned Parameter

<string>

Related Commands

NET:MAC, NET:GATE, NET:SUBN, NET:PORT, NET:HOST, NET:DHCP

5.4.3.5. NET:GATE

Description

This command sets the Gateway IP address of the Ethernet module of the power supply. The factory default Gateway IP setting is 192.168.1.1.

Command Syntax

[SYSTem][:COMMunicate]:NETwork:GATE <string>

Parameters

Gateway IP address is represented with 4 bytes each having a range of 0-255 separated by dots

Examples

SYSTem:COMM:NET:GATE 192.168.10.2
NET:GATE 192.168.10.2

Query Syntax

```
[SYSTem][:COMMunicate]:NETwork:GATE?
```

Returned Parameter

```
<string>
```

Related Commands

```
NET:MAC, NET: ADDR, NET:SUBN, NET:PORT, NET:HOST, NET:DHCP
```

5.4.3.6. NET:SUBN

Description

This command sets the subnet IP Mask address of the Ethernet module of the power supply. The factory subnet mask setting is 255.255.255.0.

Command Syntax

```
[SYSTem][:COMMunicate]:NETwork:SUBNet <string>
```

Parameters

IP mask address is represented with 4 bytes each having a range of 0-255 separated by periods.

Examples

```
SYSTem:COMM:NET:SUBNet 255.255.255.128
NET: SUBNet 255.255.255.128
```

Query Syntax

```
[SYSTem][:COMMunicate]:NETwork:SUBNet?
```

Returned Parameter

```
<string>
```

Related Commands

```
NET:MAC, NET: ADDR, NET:GATE, NET:PORT, NET:HOST, NET:DHCP
```

5.4.3.7. NET:PORT

Description

This command sets the Socket (Port) of the Ethernet module of the power supply. The factory default port setting is 50505. The factory recommends port values greater than 49151 to avoid conflicts with registered Ethernet port functions.

Command Syntax

```
[SYSTem][:COMMunicate]:NETwork:PORT <NR1>
```

Parameters

16-bit socket number (1 to 65,535)

Examples

```
SYSTem:COMM:NET: PORT 50505
NET: PORT 50505
```

Query Syntax

```
[SYSTem][:COMMunicate]:NETwork:PORT?
```

Returned Parameter

```
<NR1>
```

Related Commands

NET:MAC, NET: ADDR, NET:GATE, NET:SUBN, NET:HOST, NET:DHCP

5.4.3.8. NET:HOST?

Description

This query reads the host name of the Ethernet communications module.

Query Syntax

[SYSTem][:COMMunicate]:NETwork:HOSTname?

Examples

SYST:COMM:NET:HOST?
NET:HOST?

Returned Parameter

<string>

Related Commands

NET:MAC, NET: ADDR, NET:SUBN, NET:PORT, NET:DHCP

5.4.3.9. NET:DHCP

Description

This command sets the DHCP operating mode of the Ethernet module. If DHCP is set to 1, the module will allow its IP address to be automatically set by the DHCP server on the network. If DHCP is set to 0, the default IP address is set according to *Table 5.15, "Default LXI TCP/IP Ethernet settings (without DHCP Server)"*. The factory DHCP setting is 1.

Command Syntax

[SYSTem][:COMMunicate]:NETwork:DHCP <NR1>

Parameters

0 = DHCP Off
1 = DHCP On

Examples

SYST:COMM:NET:DHCP 0
NET:DHCP 1

Query Syntax

[SYSTem][:COMMunicate]:NETwork:DHCP?

Returned Parameter

<NR1>

Related Commands

NET:MAC, NET: ADDR, NET:GATE, NET:SUBN, NET:PORT, NET:HOST

5.5. USB Communications

Magna-Power Electronics XR Series III supports USB communication through an external RS232 to USB expansion module. The external USB Edgeport/1 (+USB) option transparently transforms a RS232 COM port to a USB.

The USB Edgeport/1 Windows drivers, included on the Magna-Power Electronics CD that ships with the power supply, installs a virtual RS232 COM port in the Device Manager of the operating system. This in turn will allow communications with the XR Series III power supply in the same manner as a device connected to the RS232 COM port on a PC. The USB port becomes transparent to the serial device and the software running on the PC.

5.5.1. USB Edgeport/1 Setup

Before installing this optional equipment, the manufacturer recommends that you first commission the system using the manual controls on the front panel of the power supply.

To connect the Edgeport/1 USB Expansion Module to the XR Series III power supply, proceed as follows:

1. Connect the USB cable between a USB port on the computer and the Edgeport USB Expansion module. This cable is supplied with the optional product.

2. If required, install the drivers for the Edgeport USB Expansion Module from the Magna-Power Electronics software CD.

3. Connect a standard, straight-through, 9-conductor, serial extension cable between connector JS3 on the power supply and the serial port on the Edgeport USB Expansion Module. This cable is supplied with the XR Series III programmable DC power supply.

4. Establish RS232 communications by configuring the power supply for REMOTE operation using the front panel commands described in *Section 3.2.3, "Configuration Commands"*

5.5.2. USB Edgeport/1 Communications Using the Remote Interface Software

Chapter 4, Remote Interface Software describes application of the Remote Interface Software that ships with XR Series III programmable DC power supply. This software provides the user with a quick method to operate a Magna-Power Electronics programmable DC power supply under computer control. The software can be configured for a number of communication interfaces.

To use Remote Interface Software with the Edgeport/1 USB Expansion Module, perform the setup described in previous section and refer to *Section 4.1, "Application Setup"* to configure the software for RS232 communications.

5.6. RS485 Communications

The optional 485DSS to RS232 converter, transparently converts data between two ports with control codes or special commands.

The Model 485DSS, RS485 distributed smart switch, allows multiple addressing of RS232 devices. The host computer uses RS485 output to send commands to the network consisting of multiple 485DSS devices interfacing to RS232 communications equipment. Each 485DSS device has a unique address that can be set from 0 to 255. The 485DSS configuration settings are detailed in *Table 5.17, "RS485 Interface Configuration"*. There is no delay or buffering of data in the 485DSS.

Table 5.17. RS485 Interface Configuration

Parameter	Value
Baud Rate	9600
Data Size	8-bit

Parameter	Value
Parity	None
Stop Bits	1
Flow Control	Off
Cable Type	Straight-through

A command is required to address each individual 485DSS module. Once addressed, the module will transparently convert serial data. The address command can only be transmitted at 9600 baud, and if the command is transmitted at any other baud rate, the command will be ignored by the 485DSS module. The address command has the following form: Xoff character, the most significant address character, the least significant address character, and SOH character. The address range of the 485DSS module is from 0 to 255 in decimal or 0 to FF in hex.

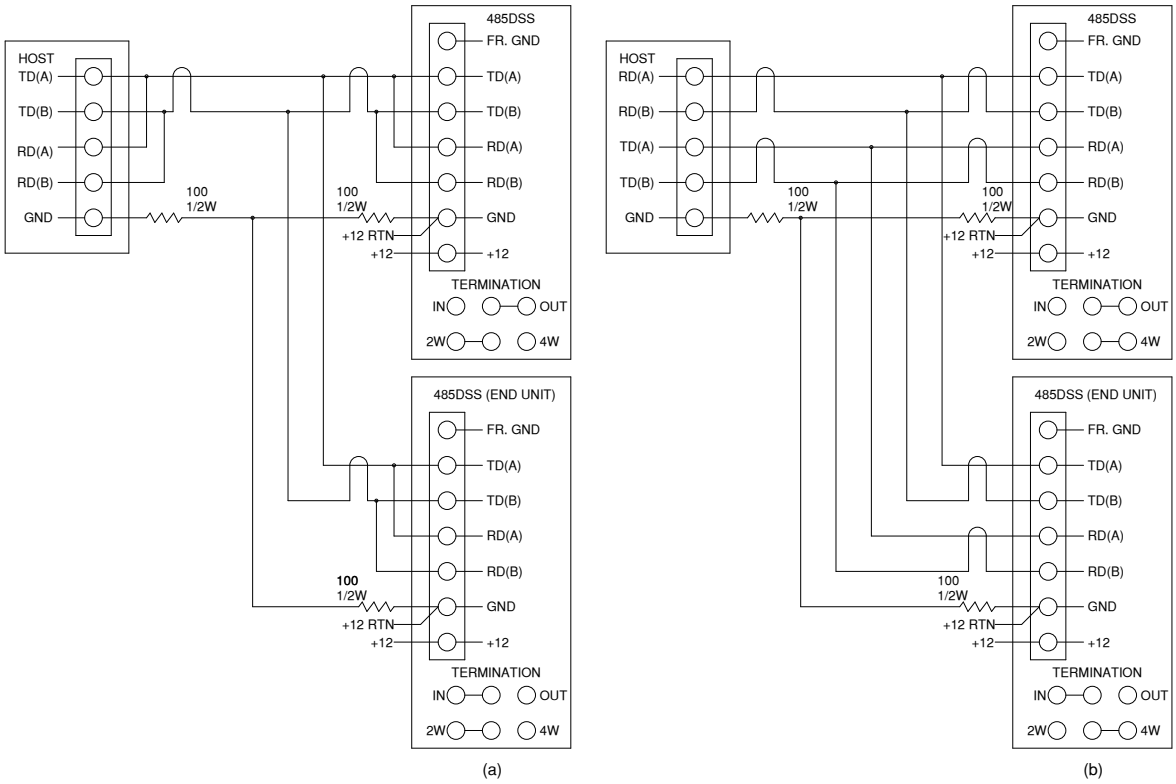

Figure 5.4. RS485 (a) 2-wire and (b) 4-wire connections

5.6.1. 485DSS Initial Setup

This section sets up the hardware for the 485DSS module.

1. The default address for the 485DSS is 0. To change this address, remove the module's cover and locate the DIP switch in the center of the printed circuit board. Set the desired address on the DIP switch using the bit weights associated with each switch.

2. Set the 485DSS for either 2-wire or 4-wire communications. Jumper settings are illustrated in *Figure 5.4, "RS485 (a) 2-wire and (b) 4-wire connections"*.

3. For noisy environments, a terminator may be required between the RD(A) and RD(B) lines. To add a terminator, set the termination jumper to IN to the 485DSS at the end of the line.

4. Connect the serial cable from the connector JS3 on the power supply to the 485DSS. This requires a male DB9 to female DB25 serial cable.

5. Establish RS232 communications by configuring the power supply for remote operation using the front panel commands described in *Section 3.2.3, "Configuration Commands"*.

5.7. IVI-COM Driver

Magna-Power Electronics IVI-COM driver handles the low-level bus protocols, simplifying automation development. It supports TCP/IP, IEEE-488 GPIB and RS232 using standard VISA resource descriptors. For additional documentation and details on using the IVI-COM driver, see the driver's included help file (MPEIVI.chm, located in 'C:\Program Files (x86)\IVI Foundation\IVI\Drivers\MPEIVI' on Windows 64-bit operating systems or in 'C:\Program Files\IVI Foundation\IVI\Drivers\MPEIVI' on Windows 32-bit operating systems). Use of this driver is highly recommended for Visual C++, Visual C#, Visual Basic .NET, Visual Basic 6.0, LabVIEW, LabWindows/CVI, MATLAB, Measure Foundry, and Agilent VEE Pro. Getting Started Guides for implementing this driver are available from the IVI Foundation: http://www.ivifoundation.org/.

As part of the prerequisite for the IVI Driver, the IVI Foundation Shared Components must be installed, as well as a VISA-COM manager, such as National Instruments NI-VISA or Agilent IO Libraries Suite. Sample projects are available for C# and Visual Basic within the Visual Studio environment. Contact `support@magna-power.com` for more information.

Applications

XR Series III power supplies deploy several powerful programming functions that enhance performance for key user specific applications. While the possibilities are endless, a few examples are presented in this chapter to demonstrate the internal capabilities of the power supply. All of these examples can be further expanded by operating the unit under computer control. Modulation functions are available for models with the XR or D-Version front panel, while applications requiring local memory stepping are only available with the D-Version front panel.

6.1. Power Waveform Generation

Magna-Power Electronics programmable DC power supply supplies with the D-Version front panel can be programmed to operate as a power waveform generator (Note: This function is not available on XR Series products). Each memory state needs to be programmed for the desired voltage or current for a specific time period. An example of a power waveform generator and its corresponding programming values are shown in *Figure 6.1, "Sawtooth Output Voltage"* and *Table 6.1, "Ramp Generator Sequential Step Program"*, respectfully. In this particular example, the voltage set point is changed in 10 second intervals while the current, over voltage trip, and over current trip are kept constant. To make the power supply repeat the voltage ramp, a time period of 9998 is entered for step 9. The programming causes the memory state to jump back to 0 after completing step 8. To start the ramp generator, set the power supply to memory state 0, press the arm key, and then the start key. Press the stop key to terminate operation.

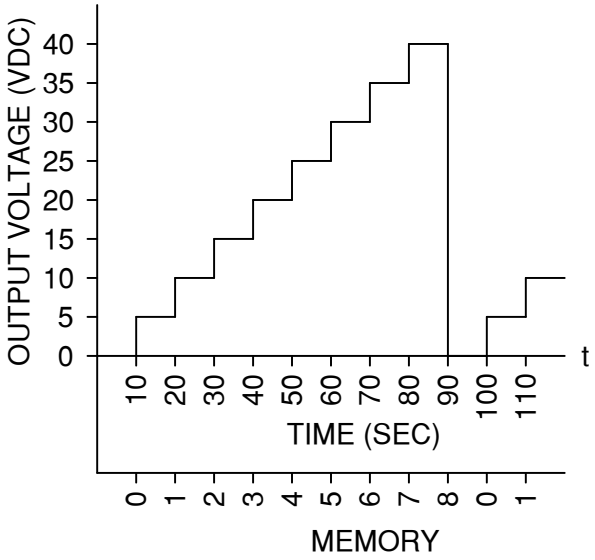

Figure 6.1. Sawtooth Output Voltage

Table 6.1. Ramp Generator Sequential Step Program

Memory	Voltage Set (Vdc)	Current Set (Adc)	Over Voltage Trip (Vdc)	Over Current Trip (Adc)	Period (s)
0	0	200	55	220	10
1	5	200	55	220	10
2	10	200	55	220	10
3	15	200	55	220	10
4	20	200	55	220	10
5	25	200	55	220	10
6	30	200	55	220	10

Memory	Voltage Set (Vdc)	Current Set (Adc)	Over Voltage Trip (Vdc)	Over Current Trip (Adc)	Period (s)
7	35	200	55	220	10
8	40	200	55	220	10
9	40	200	55	220	9998

6.2. Leadless Remote Sensing

Remote sensing is used to improve the degradation of regulation which will occur at the load when the voltage drop in the connecting wires is appreciable. Remote sensing, as described in *Section 2.4.1, "Remote Voltage Sensing"*, requires an pair of wires to be connected between the output of the power supply and the desired point of load regulation. Remote sensing can be accomplished, without the use of the additional sense leads, by calculating the voltage drop in the output leads and adjusting the output voltage accordingly.

To establish leadless remote sensing, connect terminal 24 of JS1 to terminal 25 of JS1, set the modulation control parameter to voltage control, and set the modulation type to 1. *Figure 6.2, "Leadless remote voltage sensing"* illustrates the hardware connection and *Section 5.1.6, "Modulation Commands"* describes application of the modulation subsystem. Modulation tables can be easily entered and permanently stored in the power supply using the included RIS Panel software, as described in *Section 4.7, "Modulation Panel"*. With this configuration, output voltage will increase or decrease with output current as defined by the modulation table. By programming a positive slope into the modulation table, output voltage and voltage drop due to lead loss can be made to cancel. For an installation where there is a 2% drop in voltage at full scale current, the modulation table should be programmed according to *Table 6.2, "Modulation Table for Leadless Remote Sensing (Control Type 1)"*. For row 3 in the modulation table, VMOD is given the value 9999 to signify the last entry.

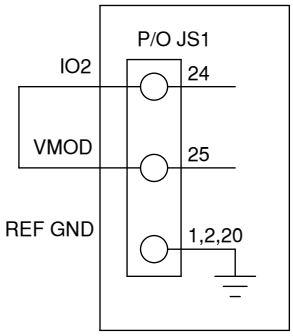

Figure 6.2. Leadless remote voltage sensing

Table 6.2. Modulation Table for Leadless Remote Sensing (Control Type 1)

Row	VMOD (Vdc)	Mod(VMOD)
1	0.0	0.00
2	10.0	0.20
3	9999	0.00

6.3. Photovoltaic Cell Simulator

Modulation enables the power supply to emulate different sources: such as batteries, fuel cells, photovoltaic arrays, etc. To simulate a photovoltaic array, connect terminal 24 of JS1 to terminal 25 of JS1, set the modulation control parameter to voltage control, and set the modulation type to 0. *Figure 6.3, "IV characteristics for a typical photovoltaic array"* illustrates the programmed piece-wise linear approximation for a typical photovoltaic array and *Table 6.3, "Modulation Table for emulation*

of a Photovoltaic Array (Control Type 0)" defines the associated piece-wise linear modulation table to emulate that array. For this example, a Magna-Power Electronics power supply rated for 125 Vdc and 53 Adc peak output was chosen for the power source. More advanced functionality and automated programming and sequencing is available using Magna-Power Electronics Photovoltaic Power Profile Emulation software.

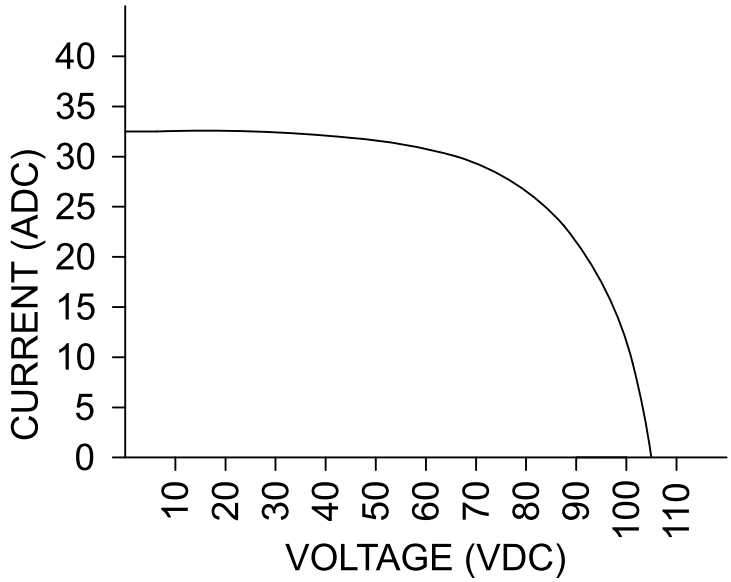

Figure 6.3. IV characteristics for a typical photovoltaic array

Table 6.3. Modulation Table for emulation of a Photovoltaic Array (Control Type 0)

Row	VMOD (Vdc)	Mod(VMOD)	Vo (Vdc)	Io (Adc)
1	0.000	1.000	105	0.0
2	1.887	0.952	100	10.0
3	3.302	0.905	95	17.5
4	4.245	0.857	90	22.5
5	4.717	0.809	85	25.0
6	4.906	0.762	80	26.0
7	5.189	0.714	75	27.5
8	5.472	0.666	70	29.0
9	5.660	0.619	65	30.0
10	5.849	0.571	60	31.0
11	6.038	0.476	50	32.0
12	6.132	0.050	0	32.5
13	9999	0.000		
Note: Set the program voltage to 105 V.				

6.4. Battery Charger

Figure 6.4, "Battery Charger with Temperature Compensation" illustrates a temperature compensated battery charger for applications with lead acid batteries. Diode D1, placed between the power supply and battery, blocks current from flowing from the battery to the power supply. This eliminates any loading on the battery when the power supply is off, but more importantly, prevents the battery from charging the power supply's output capacitors. With deployment of diode D1, remote sensing should

be applied across the battery terminals to compensate for the diode drop. By setting the voltage and current to the bulk charge voltage and maximum charge current, the power supply will initially charge the batteries in current mode control and then automatically crossover to voltage mode control when the batteries reach the desired set point. Using remote programming features, the power supply can be programmed for time dependent, sequential step operation to equalize and float charge the batteries after bulk charging. Equalization is generally not required for every charge cycle. *Table 6.4, "Charging Programming and Characteristics"* illustrates the different charging steps and *Table 6.5, "Battery Charging per Cell"* provides the recommended charging voltage per cell for different battery technologies.

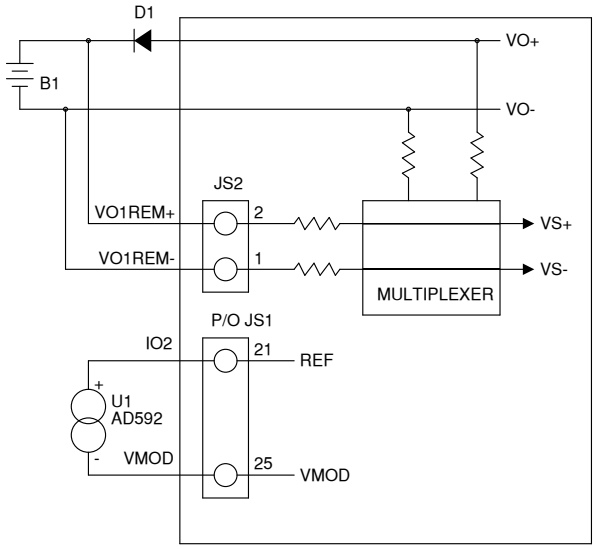

Figure 6.4. Battery Charger with Temperature Compensation

Caution: All battery parameters presented in this section are guidelines and the user should refer to and use manufacturer's specifications in any battery charging application.

A temperature detector can be applied to the modulation input to adjust the set point voltage with temperature. In this example, the temperature sensor, integrated circuit U1, is a two terminal device that produces a current proportional to temperature. This device, AD592, is manufactured by Analog Devices. The temperature detector, place between terminals 21 and 25 of connector JS1, produces a temperature dependent current. This current produces a voltage drop across the 10 K input impedance at the modulation input. *Table 6.6, "Battery Charging Temperature Compensation per Cell"* provides the recommended charge voltage deviation per cell as a function of temperature.

Table 6.7, "Modulation Table for a Temperature Compensated Battery Charger (Control Type 1)" defines the modulation parameters for applying temperature compensation to a standard 12 V lead acid battery using a Magna-Power Electronics power supply rated for 20 Vdc and 250 Adc maximum. The modulation control parameter should be set to voltage control and modulation type should be set to 1.

Table 6.4. Charging Programming and Characteristics

Parameter	Step 1: Bulk Charge	Step 2: Absorption Charge	Step 3: Equalization Charge	Step 4: Float Charge
Memory Step	0	0	1	2
Notes: Vbc: Bulk charge voltage; Vec: Equalize charge voltage; Vfc: Float charge voltage; Imbc: Maximum bulk charge current (25% of AH capacity maximum); Imec: Maximum equalization charge current (10% of AH capacity maximum)				

Parameter	Step 1: Bulk Charge	Step 2: Absorption Charge	Step 3: Equalization Charge	Step 4: Float Charge
Voltage Set	Vbc	Vbc	Vec	Vfc
Current Set	Imbc	Imbc	Imec	Imec
OVT	105% Vbc	105% Vbc	105% Vec	105% Vfc
OCT	110% Imbc	110% Imbc	110% Imec	110% Imec
Period	6 hours	6 hours	1 hour	
Mode of Control	Current	Voltage	Current/Voltage	Voltage
Notes: Vbc: Bulk charge voltage; Vec: Equalize charge voltage; Vfc: Float charge voltage; Imbc: Maximum bulk charge current (25% of AH capacity maximum); Imec: Maximum equalization charge current (10% of AH capacity maximum)				

Table 6.5. Battery Charging per Cell

		Charging Voltage Range	
Battery Type	**Bulk Vbc (Vdc)**	**Equalize Vec (Vdc)**	**Float Vfc (Vdc)**
Wet Standard (Sb/Sb) Deep Cycle	2.417 - 2.467	2.567 - 2.667	2.167 - 2.200
Wet Low Maintenance (Sb/Ca)	2.400 - 2.433	2.517 - 2.733	2.183 - 2.200
Wet Maintenance Free (Ca/Ca)	2.467	2.583 - 2.717	2.183 - 2.233
VRLA AGM	2.400 - 2.467	NA	2.200 - 2.300
VRLA Gel Cell	2.350 - 2.400	NA	2.200 - 2.300
Notes: Ca: Calcium; Sb: Antimony; VRLA: Valve regulated lead acid; AGM: Sealed absorbed Glass Mat, also known as started electrolyte			

Table 6.6. Battery Charging Temperature Compensation per Cell

Electrolyte Temperature (°F)	Electrolyte Temperature (°C)	Deviation in Charge voltage (Vdc)	
		+/-	Range
0	-17.8	+	.224 - .264
10	-12.2	+	.196 - .231
20	-6.7	+	.168 - .198
30	-1.1	+	.140 - .165
40	4.4	+	.112 - .132
50	10.0	+	.084 - .099
60	15.6	+	.056 - .066
70	21.1	+	.028 - .033
80	26.7		0.000
90	32.2	-	.028 - .033
100	37.8	-	.056 - .066
110	43.3	-	.084 - .099
Deviation is 2.80 to 3.30 mV/°F/cell			

Electrolyte Temperature (°F)	Electrolyte Temperature (°C)	Deviation in Charge voltage (Vdc)	
		+/-	Range
120	48.9	-	.112 - .132
130	54.4	-	.140 - .165
140	60.0	-	.168 - .198
150	65.6	-	.196 - .231
160	71.1	-	.224 - .264
Deviation is 2.80 to 3.30 mV/°F/cell			

Table 6.7. Modulation Table for a Temperature Compensated Battery Charger (Control Type 1)

Row	VMOD (Vdc)	Mod(VMOD)	Vo (Vdc)
1	0.000	0.73	16.10
2	0.636	0.73	16.10
3	0.858	-0.73	13.18
4	10.000	-0.73	13.18
5	9999	0.000	0
Note: Set the program voltage to 14.64V.			

6.5. Constant Power Operation

Using modulation, Magna-Power Electronics programmable DC power supplies can operate with constant power output. *Table 6.8, "Example Modulation Table for Constant Power Output (Control Type 0)"* and resulting curve *Figure 6.5, "Constant power output curve used in example modulation table"* illustrate a simple example of Control Type 0 modulation as applied to a 100 V, 150 A power supply. In this example, the power supply is programmed to produce a constant power output. Current, Io, is used as the programming operator for Mod. The method requires Io to be monitored and applied to the programming or modulation input, VMOD. As illustrated, VMOD is set to linearly respond to current.

$V_o = G_v[V_{set} \times Mod(VMOD)]$ Equation 1

$V_{ofs} = G_v \times V_{set}$ Equation 2

$VMOD = I_o \times R_x$ Equation 3

Multiply both sides of Equation 1 by I_o gives

$V_o \times I_o = P_o = V_{ofs} \times Mod(I_o \times R_x) \times I_o$ Equation 4

$Mod(I_o \times R_x) = [P_o / V_{ofs}] \times [1 / I_o]$ Equation 5

Table 6.8. Example Modulation Table for Constant Power Output (Control Type 0)

Row	VMOD (Vdc)	Mod(VMOD)	Vo (Vdc)	Io (Adc)	Po (W)
1	2.50	1.00	100.00	37.50	3750.00
2	2.94	0.850	85.00	44.12	3750.00
3	3.57	0.700	70.00	53.57	3750.00
4	4.55	0.550	55.00	68.18	3750.00
5	6.25	0.400	40.00	93.75	3750.00
6	10.00	0.250	25.00	150.00	3750.00

Piecewise linear approximation makes a continuous curve by interpolating points on the curve between those programmed. For example, Vo is 77.5 Vdc if the operating current is 48.85 Adc. For nonlinear curves, accuracy of the approximation improves with more data points.

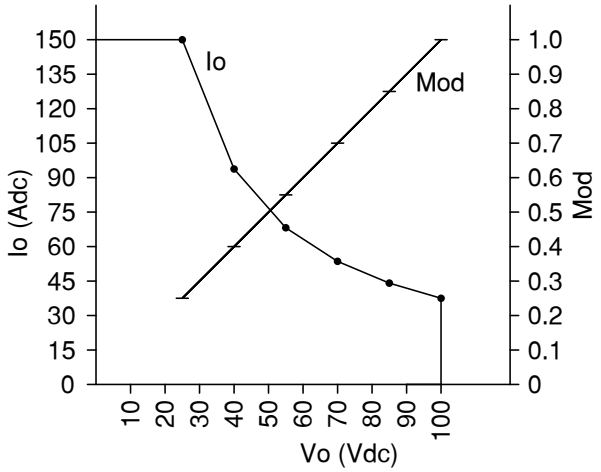

Figure 6.5. Constant power output curve used in example modulation table

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Published by
Magna-Power Electronics, Inc.
Flemington, NJ 08822 USA

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